FEDERAL EMERGENCY MANAGEMENT AGENCY

Postearthquake Safety Evaluation of Buildings

ATC-20

Original ATC-20 Document Developed by:

APPLIED TECHNOLOGY COUNCIL

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FEDERAL EMERGENCY MANAGEMENT AGENCY

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APPLIED TECHNOLOGY COUNCIL
Redwood City, California
Principal Investigator: Christopher Rojahn

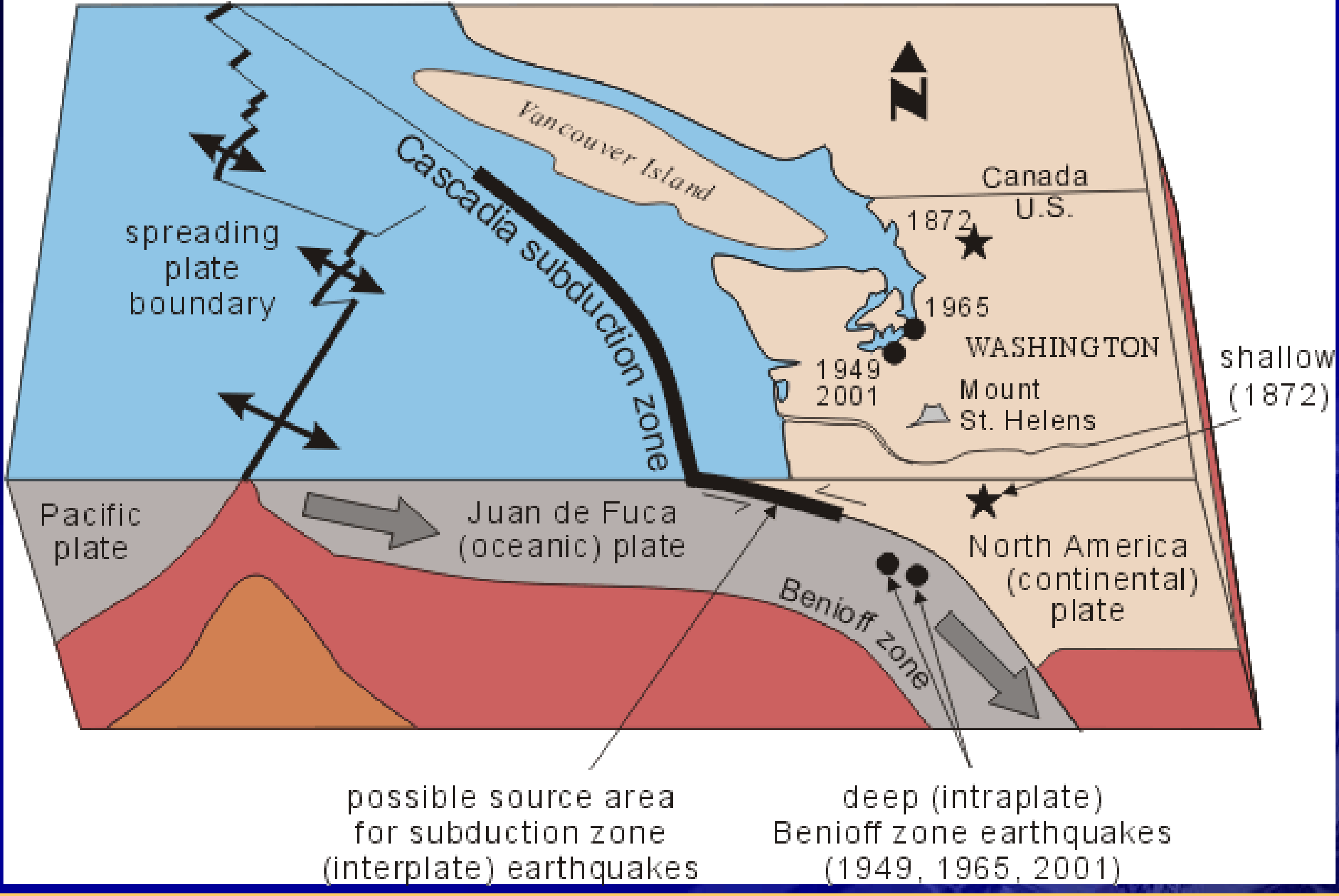
Prepared for ATC by:

R. P. GALLAGHER ASSOCIATES, INC.
San Francisco, California
Principal-in-Charge: Ronald P. Gallagher

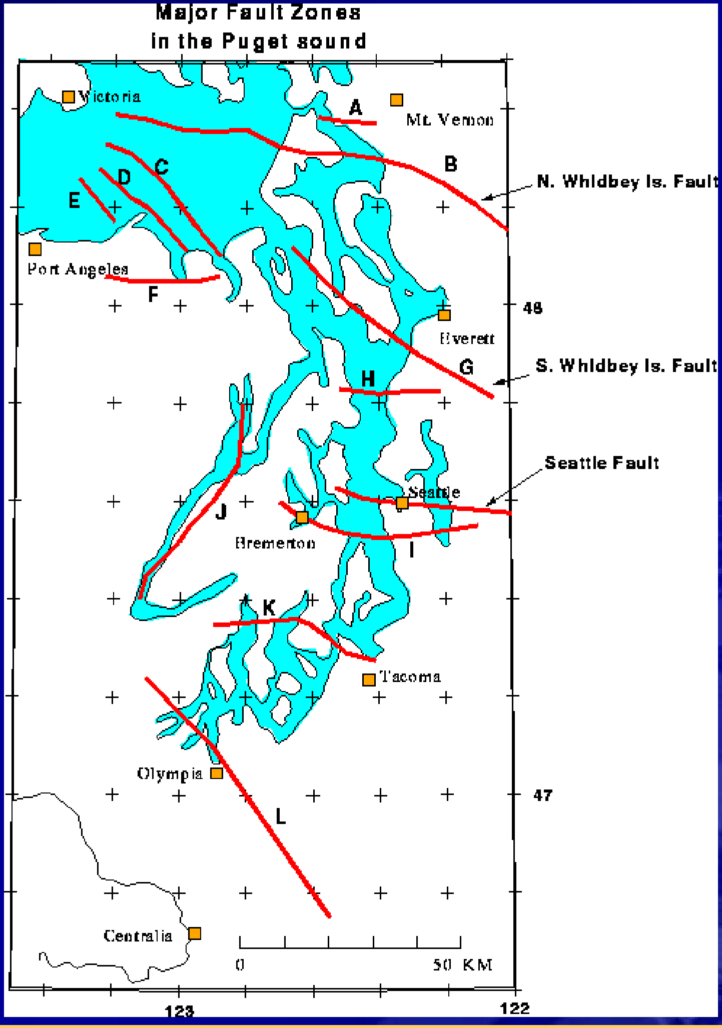
INTRODUCTION

- Seismic Hazard Overview
- Building Evaluation Considerations

Pacific Northwest Tectonic Mechanism


Vancouver Island
Cascadia subduction zone
N
Canada
U.S.
1872
1965
WASHINGTON
1949
2001
Mount St. Helens
spreading plate boundary
shallow (1872)
Pacific plate
Juan de Fuca (oceanic) plate
North America (continental) plate
Benioff zone
possible source area for subduction zone (interplate) earthquakes
deep (intraplate) Benioff zone earthquakes (1949, 1965, 2001)

Puget Sound Fault Zones



Tsunamis

- Mostly not an issue for Puget Sound
- Could be major issue on coast in Cascadia subduction event

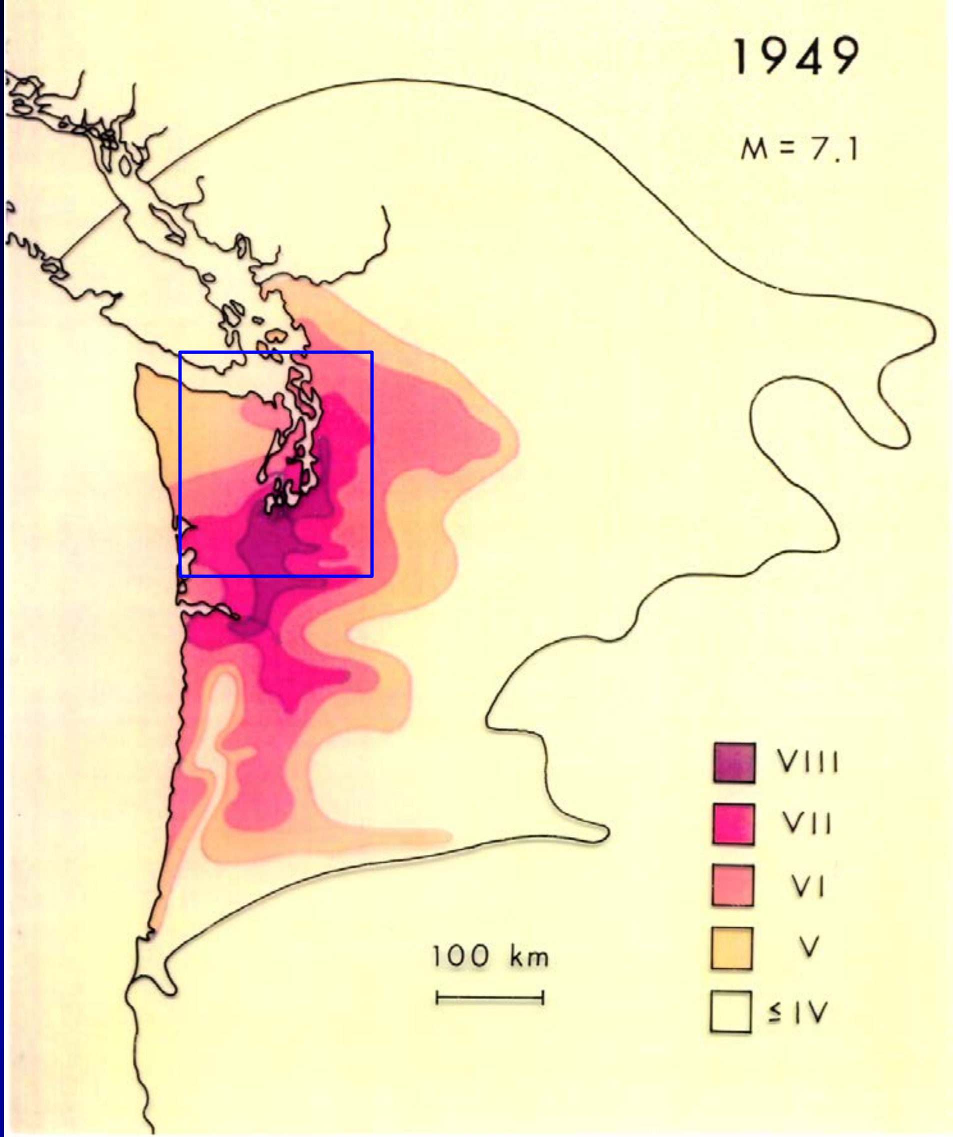
RICHTER SCALE

Richter Magnitude	4	➡	6	➡	8
Energy Increase Ratio		1,000		1,000	

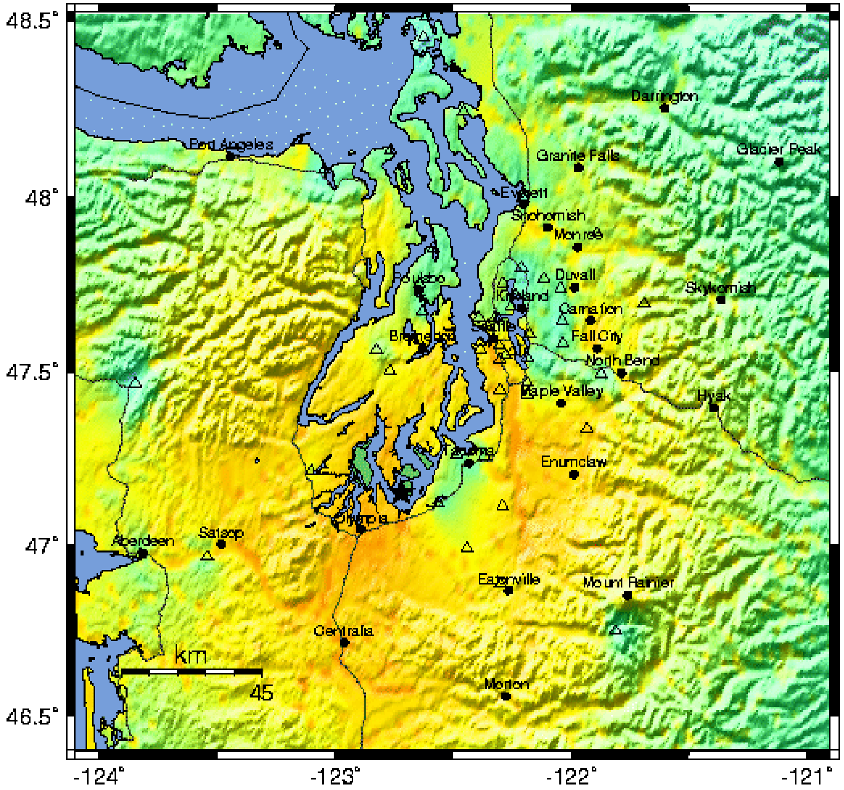
MODIFIED MERCALLI INTENSITY SCALE

MMI VI	Windows broken. Books off shelves.Weak plaster cracked.
MMI VII	Damage to weakest masonry. Weak chimneys broken. Fall of plaster, loose bricks, tiles, unbraced parapets.
MMI VIII	Damage to weak masonry, partial collapse. Frame houses moved on foundations.

1949 Olympia (M7.1) & 2001 Nisqually (M6.8) Earthquakes



PNSN Rapid Instrumental Intensity Map Epicenter: 17.6 km NE of Olympia, WA
Wed Feb 28, 2001 10:54:00 AM PST M 6.8 N47.15 W122.72 ID:0102281854



PROCESSED: Sun Apr 14, 2002 09:02:48 PM PDT, – NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

BASIC APPROACH

- Principal safety concerns:
  - —Collapse, partial collapse, structural instability
  - —Falling hazards
  - —Other hazards
- Assume significant aftershocks will occur, depending on EQ mechanism
- Focus on hazards to life & limb – not habitability or usability
  - —Emphasis on keeping people in buildings

FIELD SAFETY

- Work in teams of two
- Wear a hard hat
- Survey building before entering, enter only if safe
- Avoid hazardous materials
- Be alert for falling objects
- In case of fire, evacuate area and alert fire department
- Avoid downed power lines
- Report gas leaks

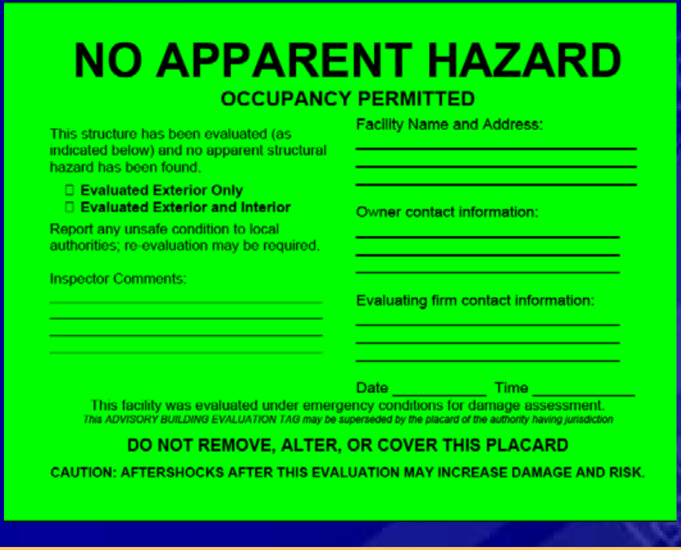
ATC-20-1:96

POSTING SYSTEM

- INSPECTED/NO APPARENT HAZARD (Green): Minimal damage, if any. No restrictions on entry at this time.
- LIMITED ENTRY/RESTRICTED USE (Yellow): Damage makes all or part of building dangerous to enter. Some restriction on use (see placard).
- UNSAFE (Red): Major damage. No entry allowed.

INSPECTED/
NO APPARENT HAZARD

- Observed damage, if any, does not appear to pose a safety risk
- Entry, occupancy, and use permitted



NO APPARENT HAZARD

OCCUPANCY PERMITTED

This structure has been evaluated (as indicated below) and no apparent structural hazard has been found.

☐ **Evaluated Exterior Only**
☐ **Evaluated Exterior and Interior**

Report any unsafe condition to local authorities; re-evaluation may be required.

Inspector Comments: ____________________

Facility Name and Address: ____________________

Owner contact information: ____________________

Evaluating firm contact information: ____________________

Date ___________ Time ___________

This facility was evaluated under emergency conditions for damage assessment.

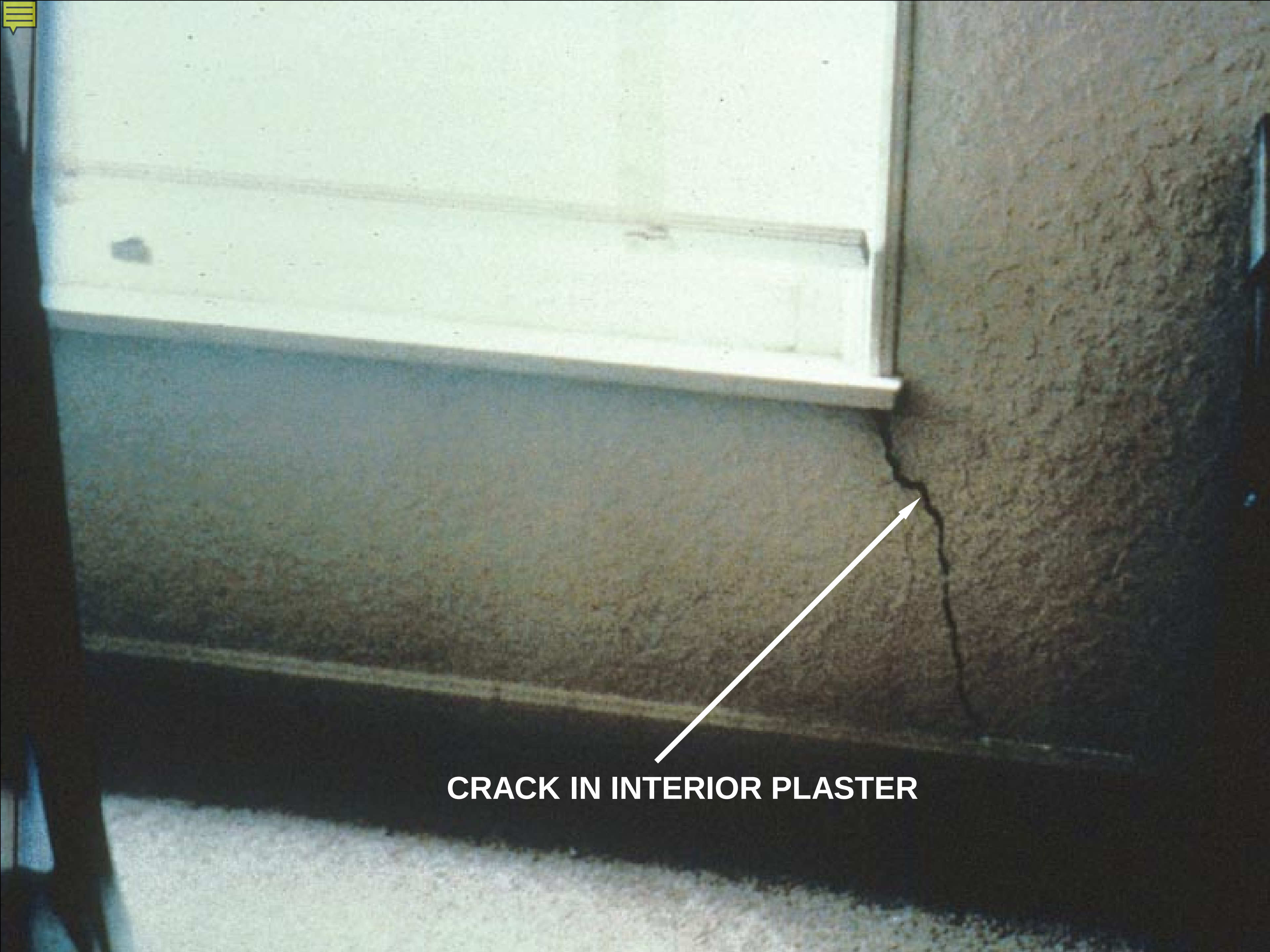
This ADVISORY BUILDING EVALUATION TAG may be superseded by the placard of the authority having jurisdiction

DO NOT REMOVE, ALTER, OR COVER THIS PLACARD

CAUTION: AFTERSHOCKS AFTER THIS EVALUATION MAY INCREASE DAMAGE AND RISK.

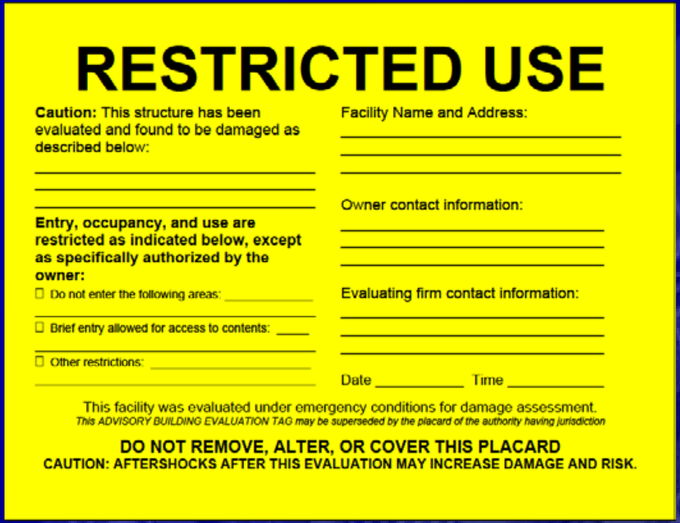
INSPECTED/ NO APPARENT HAZARD

- No evidence of major structural damage (including foundation), structure is plumb
- No falling or other life-safety risks
- No evidence of ground displacement
- Main exits usable (including doors)
- No other apparent unsafe condition
- Caveat: damage can accumulate


CRACK IN INTERIOR PLASTER

LIMITED ENTRY/ RESTRICTED USE

- Some safety risk from damage in all or part of building
- Restricted
  - —duration of occupancy
  - —areas of occupancy
  - —usage
- Covers broad range of damage



RESTRICTED USE

Caution: This structure has been evaluated and found to be damaged as described below:

____

____

____

Entry, occupancy, and use are restricted as indicated below, except as specifically authorized by the owner:

☐ Do not enter the following areas: __________

☐ Brief entry allowed for access to contents: ____

☐ Other restrictions: ________________

Facility Name and Address:

____

Owner contact information:

____

Evaluating firm contact information:

____

Date __________ Time __________

This facility was evaluated under emergency conditions for damage assessment.

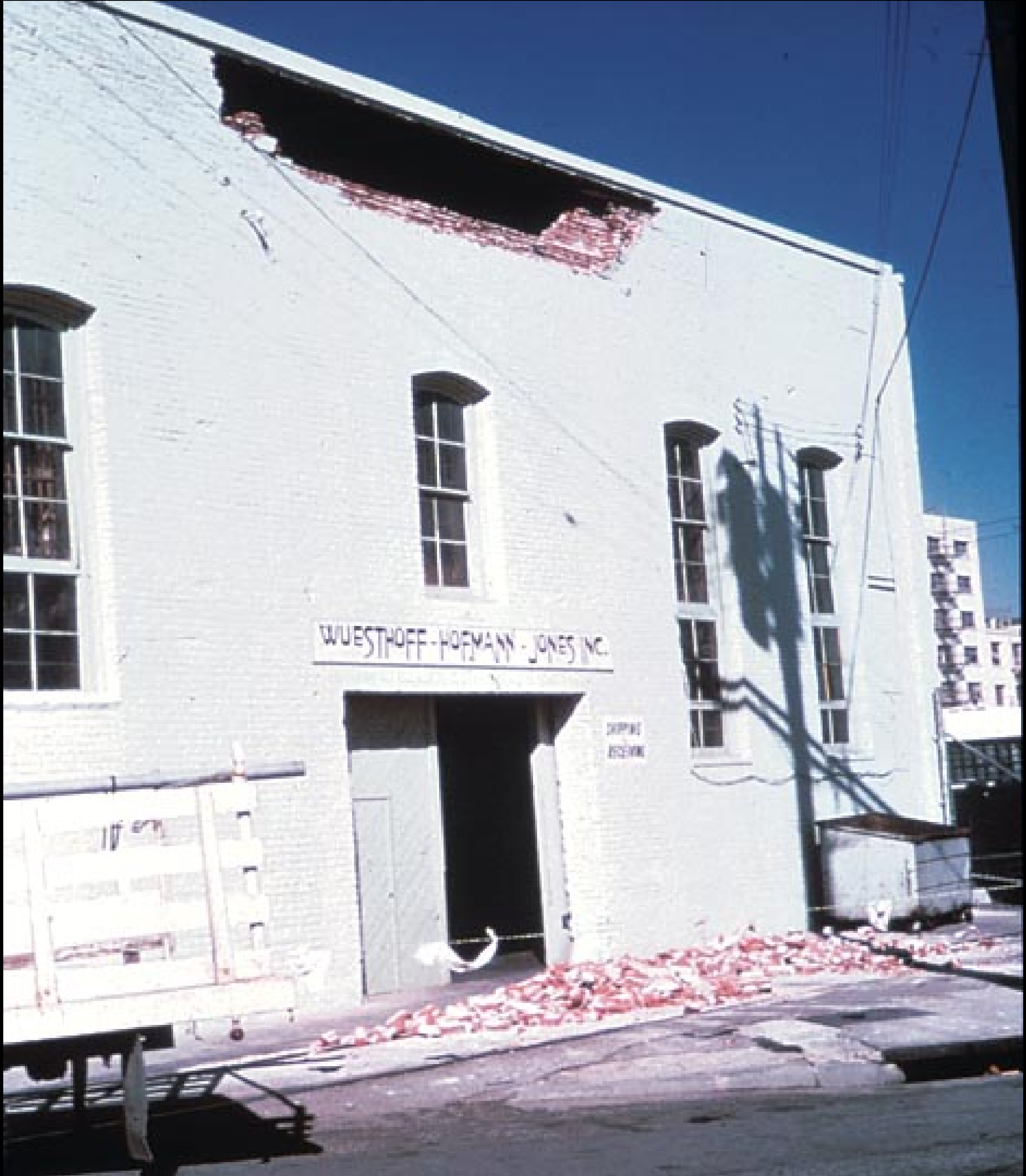
This ADVISORY BUILDING EVALUATION TAG may be superseded by the placard of the authority having jurisdiction

DO NOT REMOVE, ALTER, OR COVER THIS PLACARD

CAUTION: AFTERSHOCKS AFTER THIS EVALUATION MAY INCREASE DAMAGE AND RISK.

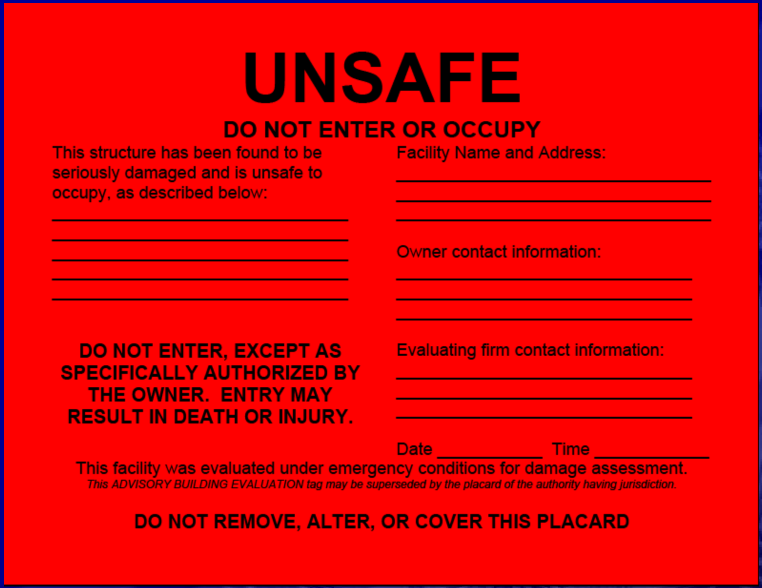
LIMITED ENTRY/ RESTRICTED USE

- Safety issues can only be resolved by removal of architectural elements or by an Engineering Evaluation
- Cladding damage may result in further damage
- Interior finish or ceiling damage may lead to falling hazards or air quality issues
- Possible presence of other risks (toxic materials release, etc.)
- Portion of the building cannot be safely occupied


WUESTHOFF - HOFMANN - JONES INC.
SHIPPING
RECEIVING

UNSAFE

- Falling, collapse, or other hazard
- Does not necessarily indicate that demolition is required
- No entry permitted



UNSAFE

DO NOT ENTER OR OCCUPY

This structure has been found to be seriously damaged and is unsafe to occupy, as described below:

Facility Name and Address:

Owner contact information:

Evaluating firm contact information:

DO NOT ENTER, EXCEPT AS SPECIFICALLY AUTHORIZED BY THE OWNER. ENTRY MAY RESULT IN DEATH OR INJURY.

Date ____________ Time ____________

This facility was evaluated under emergency conditions for damage assessment.

This ADVISORY BUILDING EVALUATION tag may be superseded by the placard of the authority having jurisdiction.

DO NOT REMOVE, ALTER, OR COVER THIS PLACARD

UNSAFE

- Obvious safety risks are present
- Structure is believed to be in danger of collapse from static conditions, subsequent events, or addition of occupant loads
- Another dangerous condition is present

PLACARDS IN SEATTLE

- Multiple languages
  - Warning text only (call number for information)
- “Advisory Tags”
  - Private sector engineers hired by building owner
  - Other City departments
  - English only
  - “Advisory” in small print

RESTRICTED USE

Caution: This structure has been evaluated and found to be damaged as described below:

____

____

____

Entry, occupancy, and use are restricted as indicated below, except as specifically authorized by the owner:

☐ Do not enter the following areas: ______________

____

☐ Brief entry allowed for access to contents: _____

____

☐ Other restrictions: ______________________

____

Facility Name and Address:

____

____

____

Owner contact information:

____

____

____

Evaluating firm contact information:

____

____

____

Date ______________ Time ______________

This facility was evaluated under emergency conditions for damage assessment.

This ADVISORY BUILDING EVALUATION TAG may be superseded by the placard of the authority having jurisdiction

DO NOT REMOVE, ALTER, OR COVER THIS PLACARD

CAUTION: AFTERSHOCKS AFTER THIS EVALUATION MAY INCREASE DAMAGE AND RISK.

EVALUATION PROCEDURES

EVALUATION LEVELS

Windshield – Overall scope of damage

Rapid – Assessment sufficient for most buildings

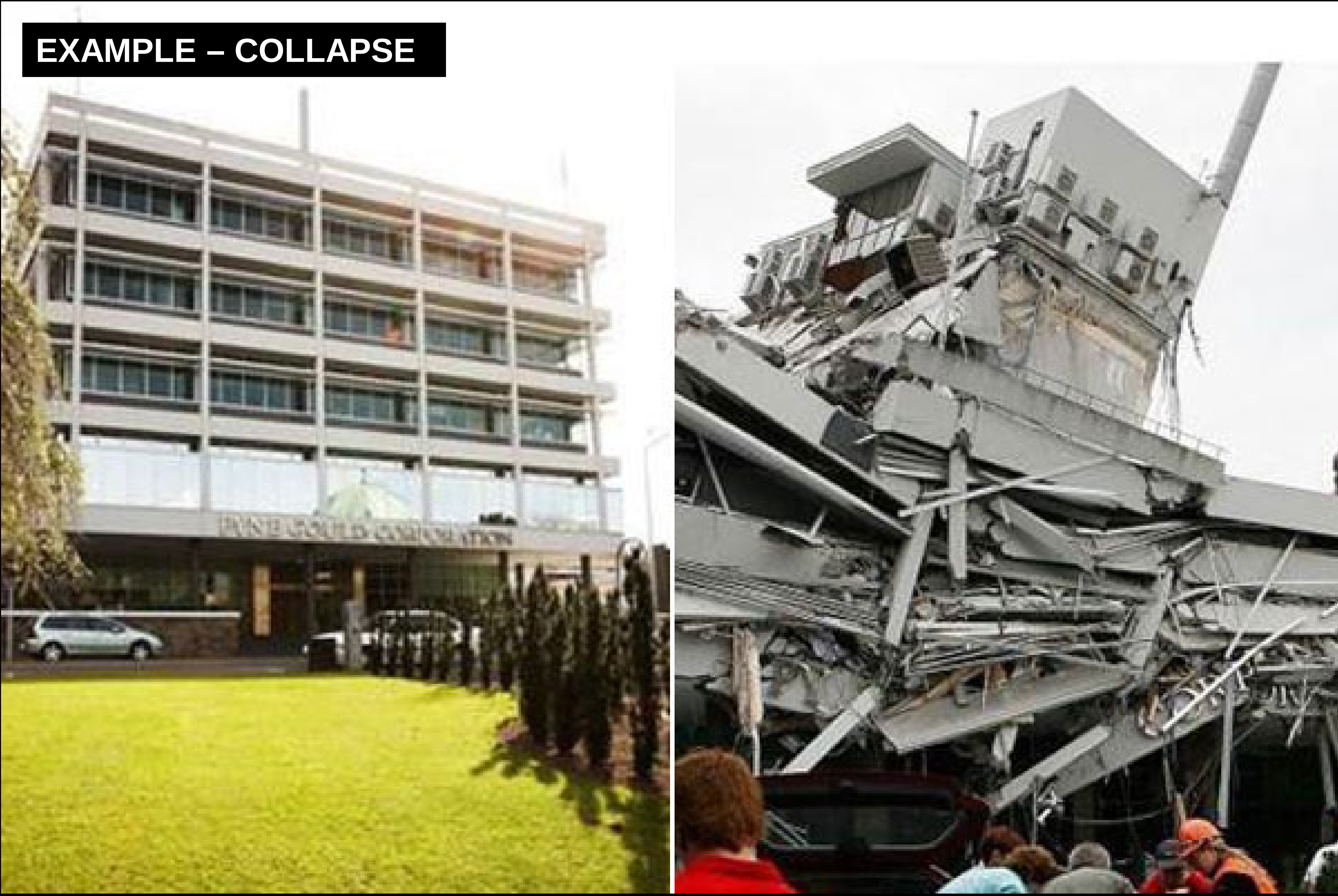
Detailed – Closer assessment of difficult and essential buildings

Engineering – Consultant engaged by owner

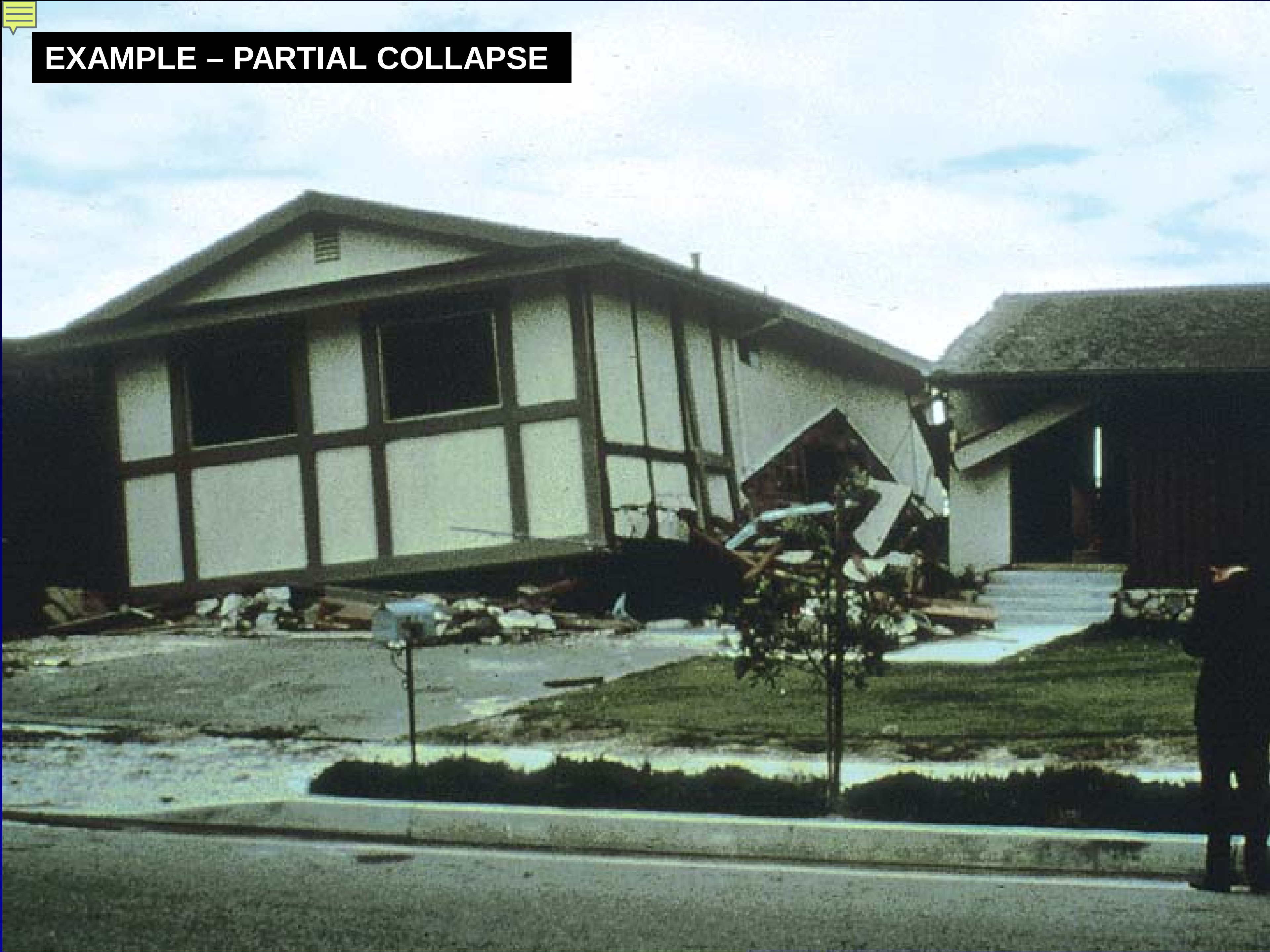
RAPID EVALUATION CRITERIA

- Collapse, partial collapse
- Building or story noticeably leaning
- Severe racking of walls, obvious severe damage
- Chimney, parapet, or other falling hazard
- Severe ground displacement or foundation damage
- Other hazard present

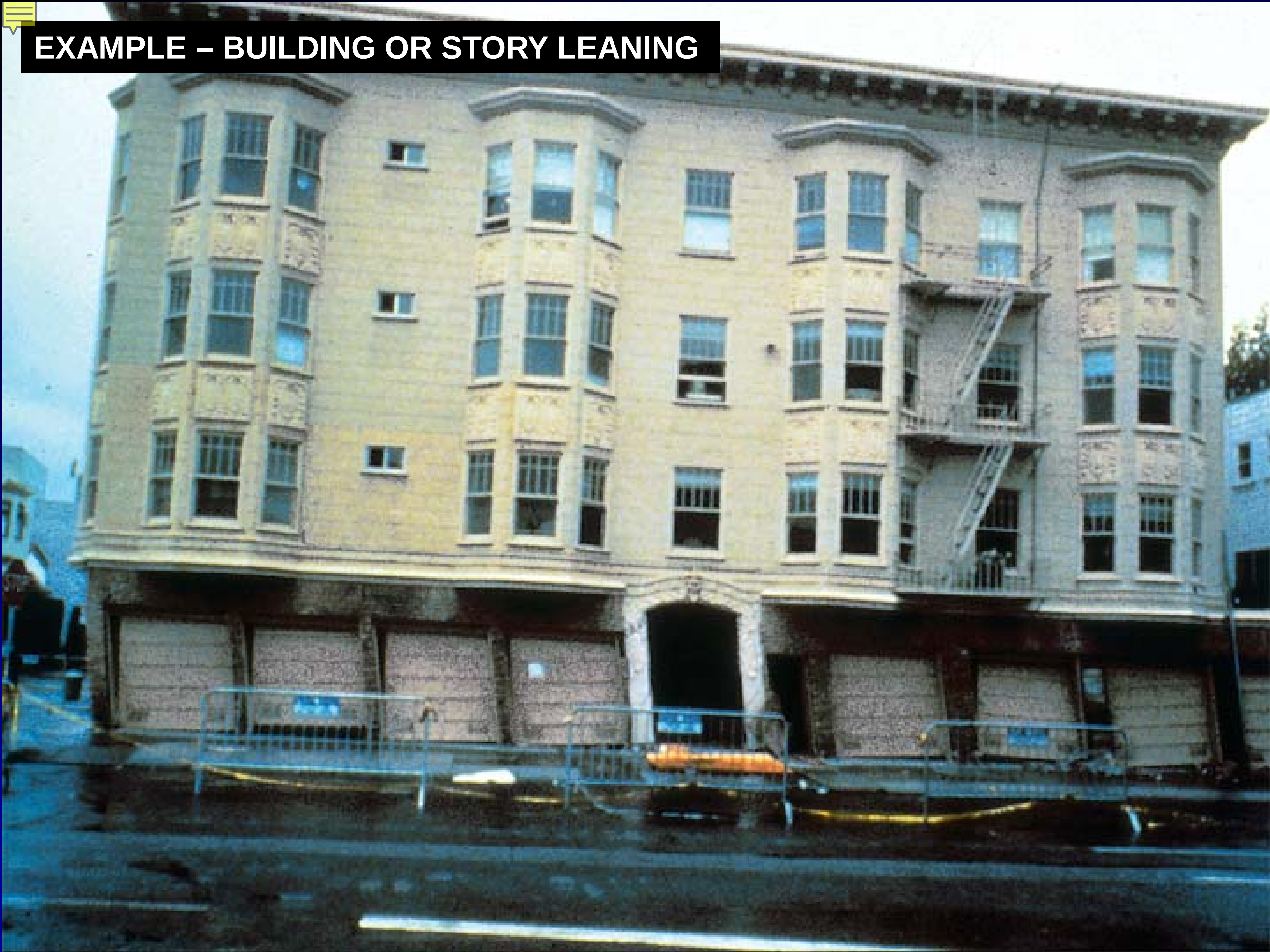
EXAMPLE – COLLAPSE



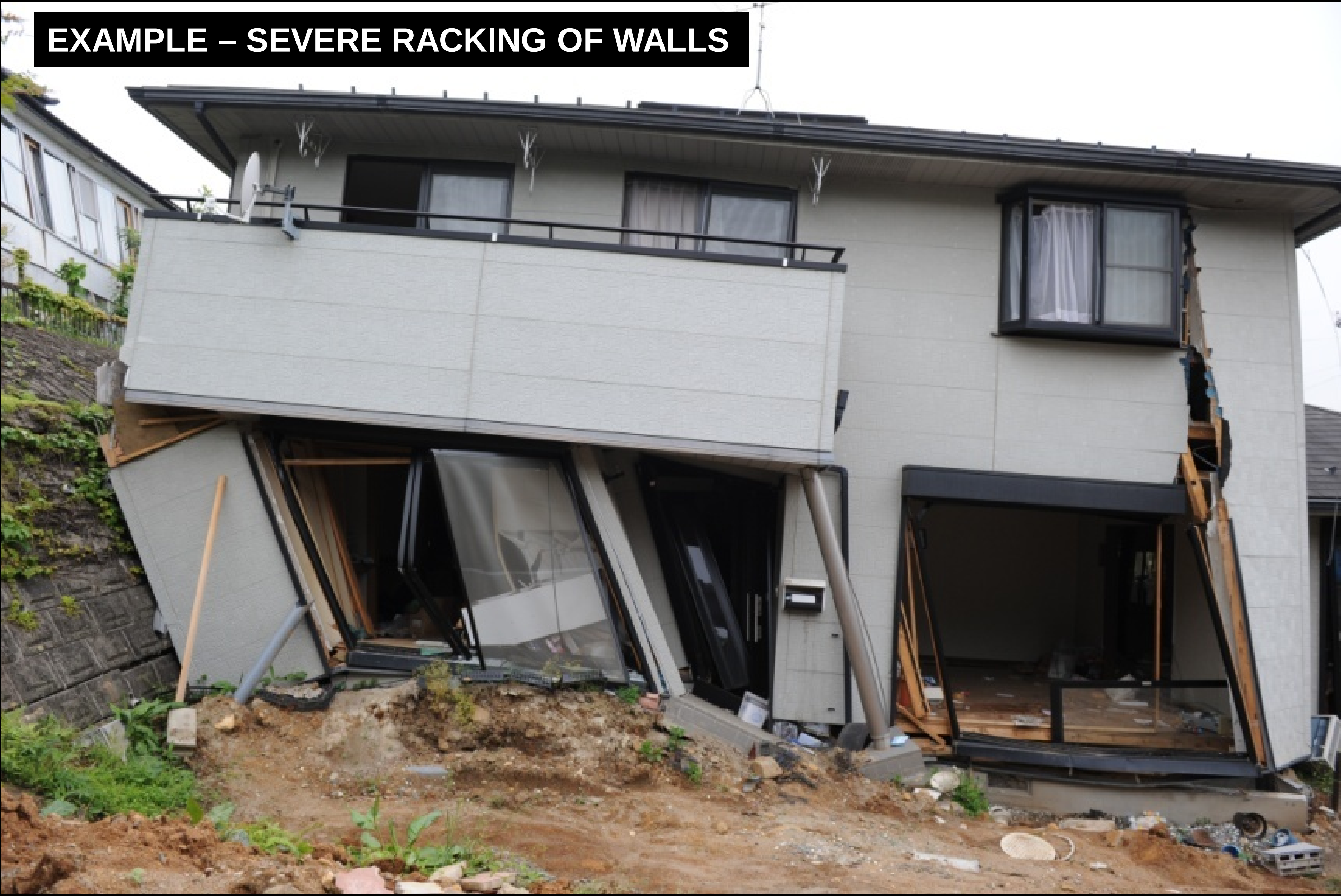
EXAMPLE – PARTIAL COLLAPSE



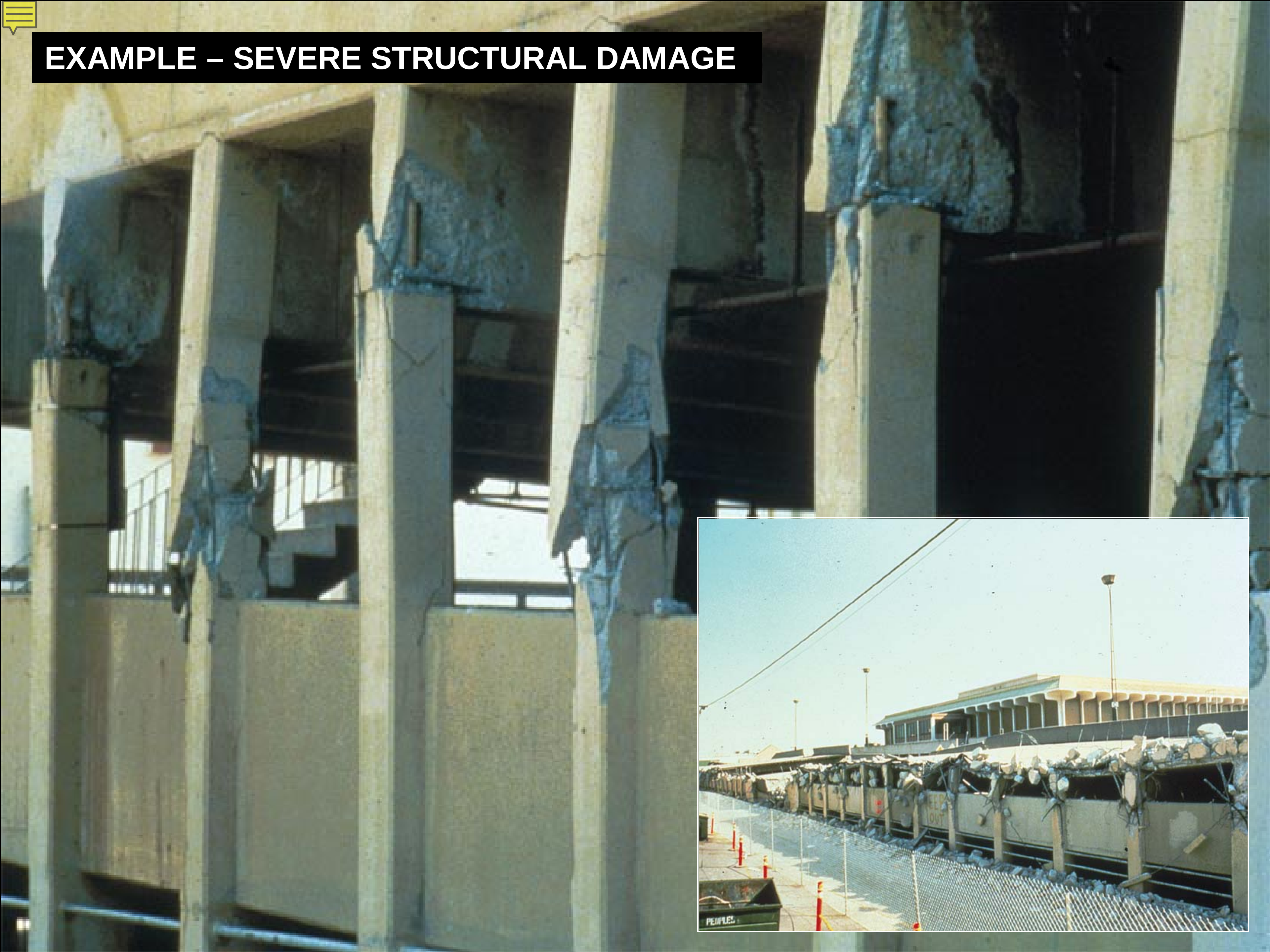
EXAMPLE – BUILDING OR STORY LEANING



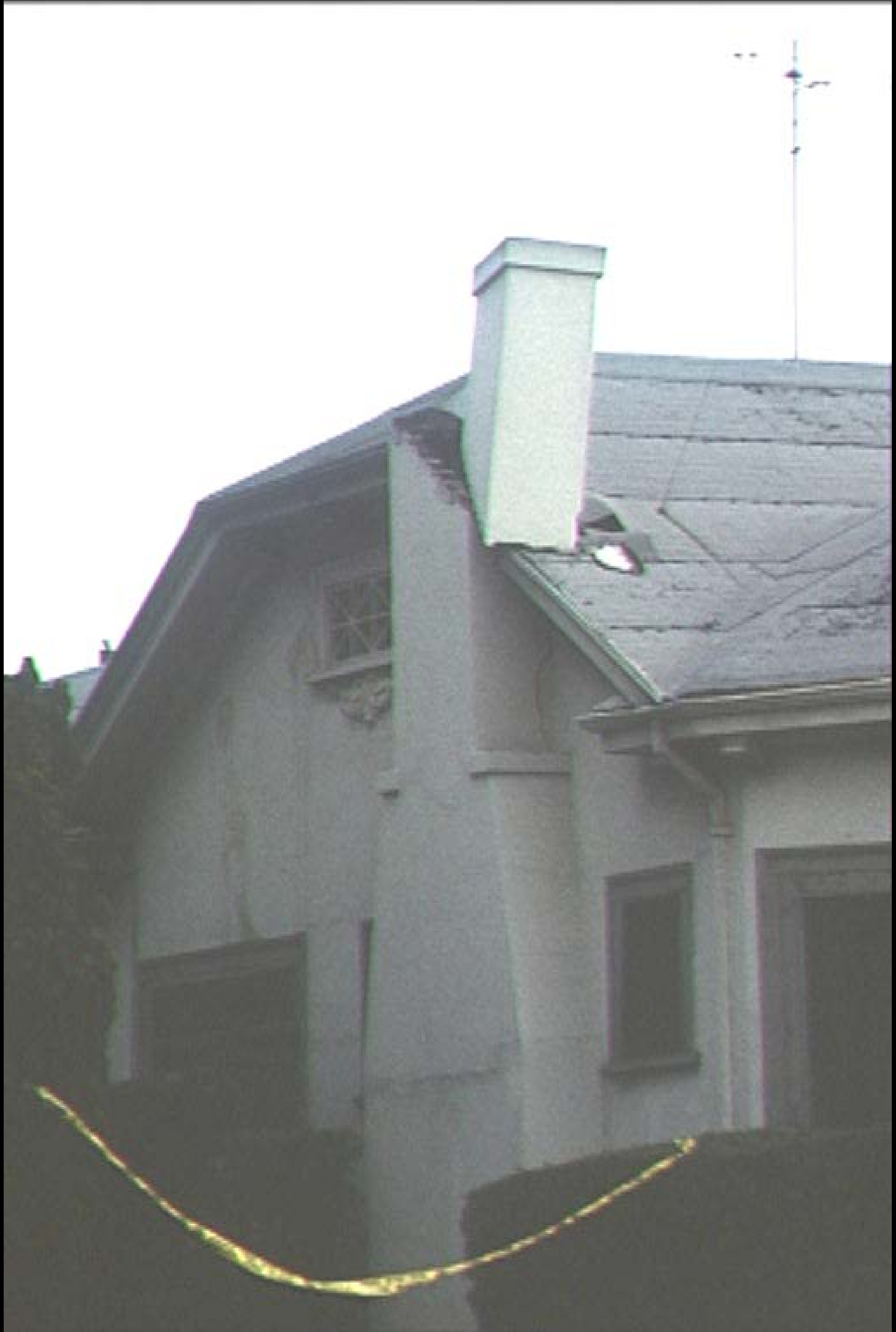
EXAMPLE – SEVERE RACKING OF WALLS

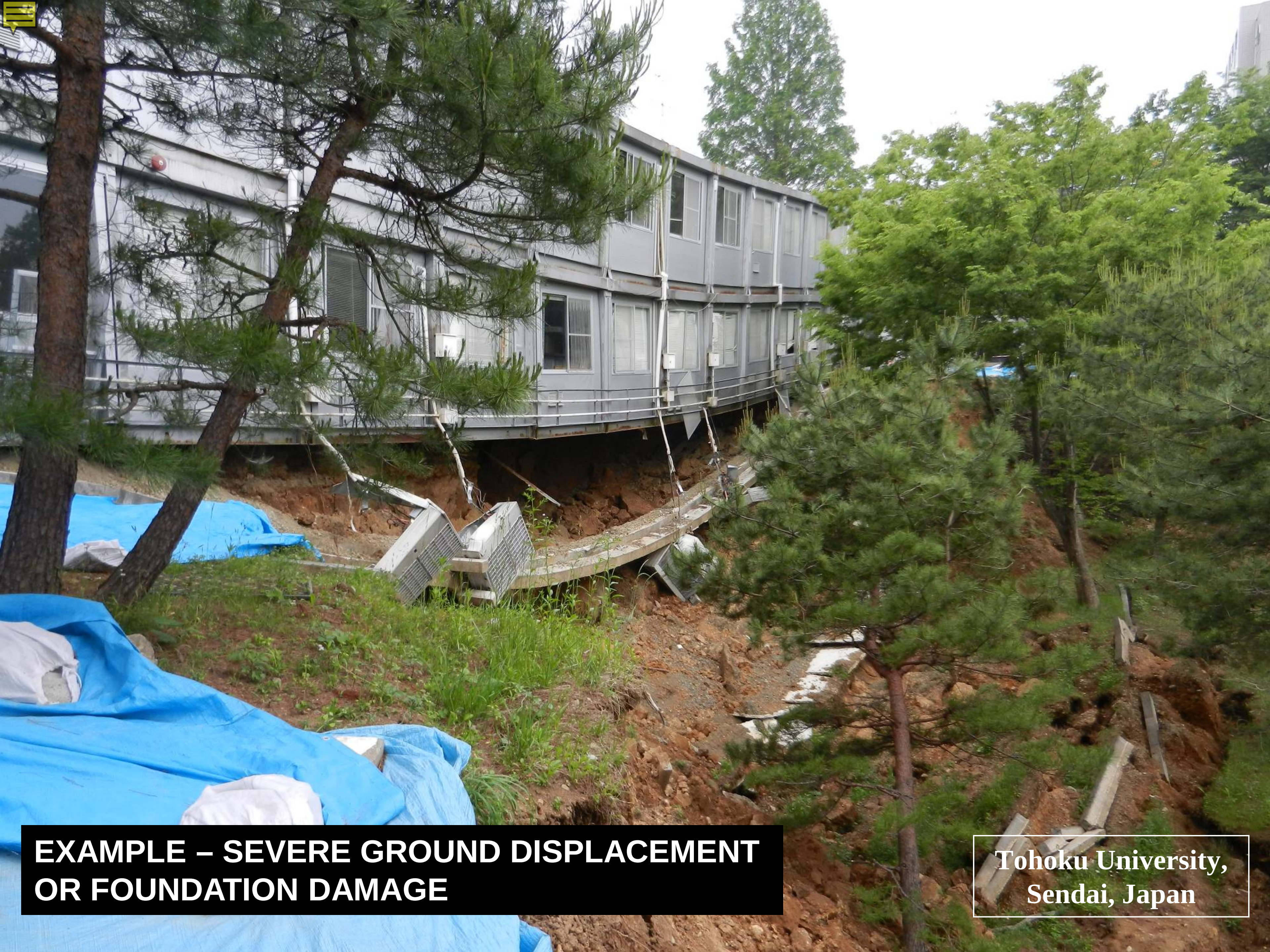


EXAMPLE – SEVERE STRUCTURAL DAMAGE



EXAMPLE – CHIMNEY, PARAPET, OR OTHER FALLING HAZARD





EXAMPLE – SEVERE GROUND DISPLACEMENT OR FOUNDATION DAMAGE

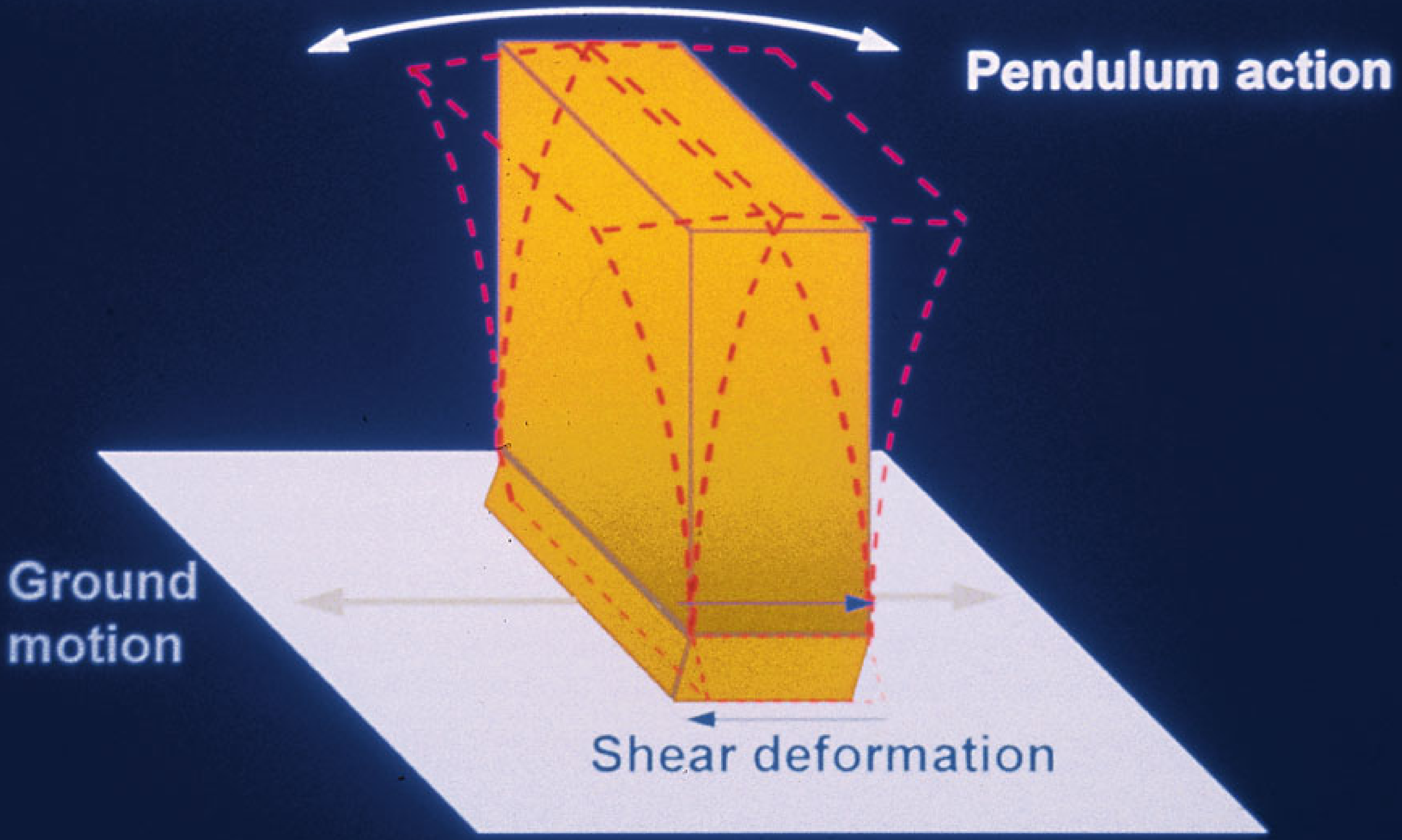
Tohoku University,
Sendai, Japan

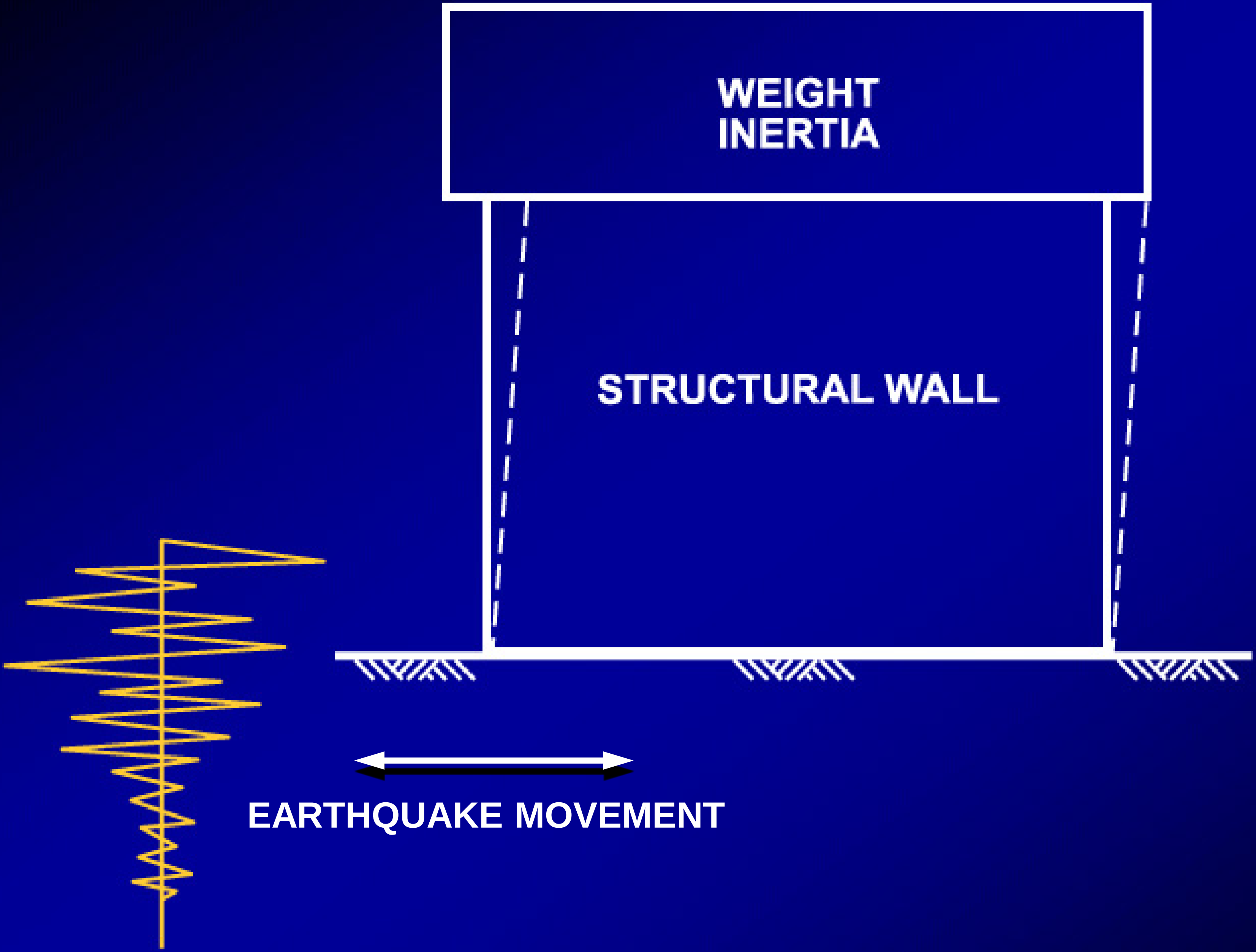
EXAMPLE – OTHER HAZARD (EXIT NOT USABLE)

STRUCTURAL BASICS

- Walls and frames
- Degradation of structural
  - Strength
  - Stiffness
  - Stability

Building Dynamic Behavior

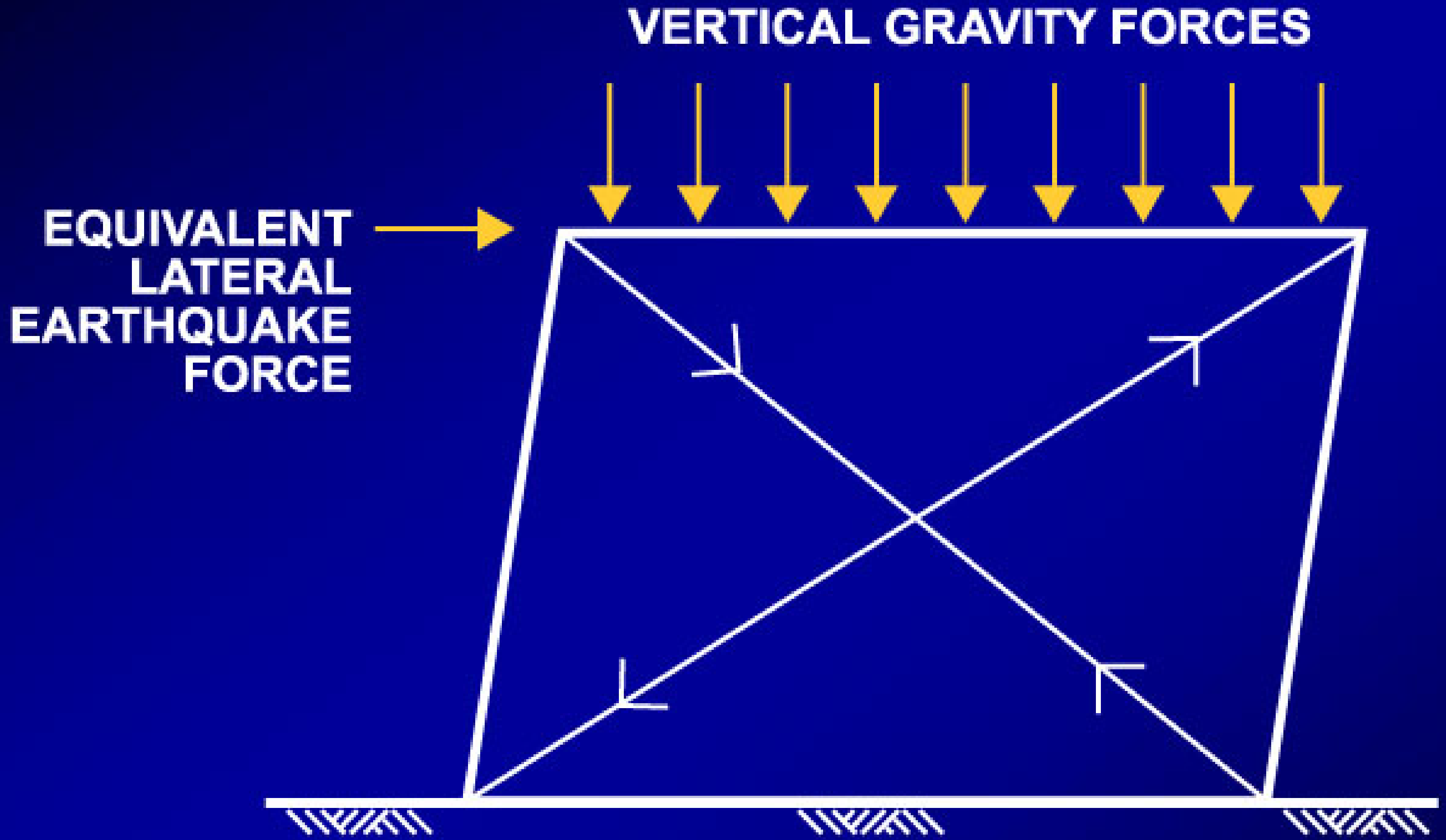




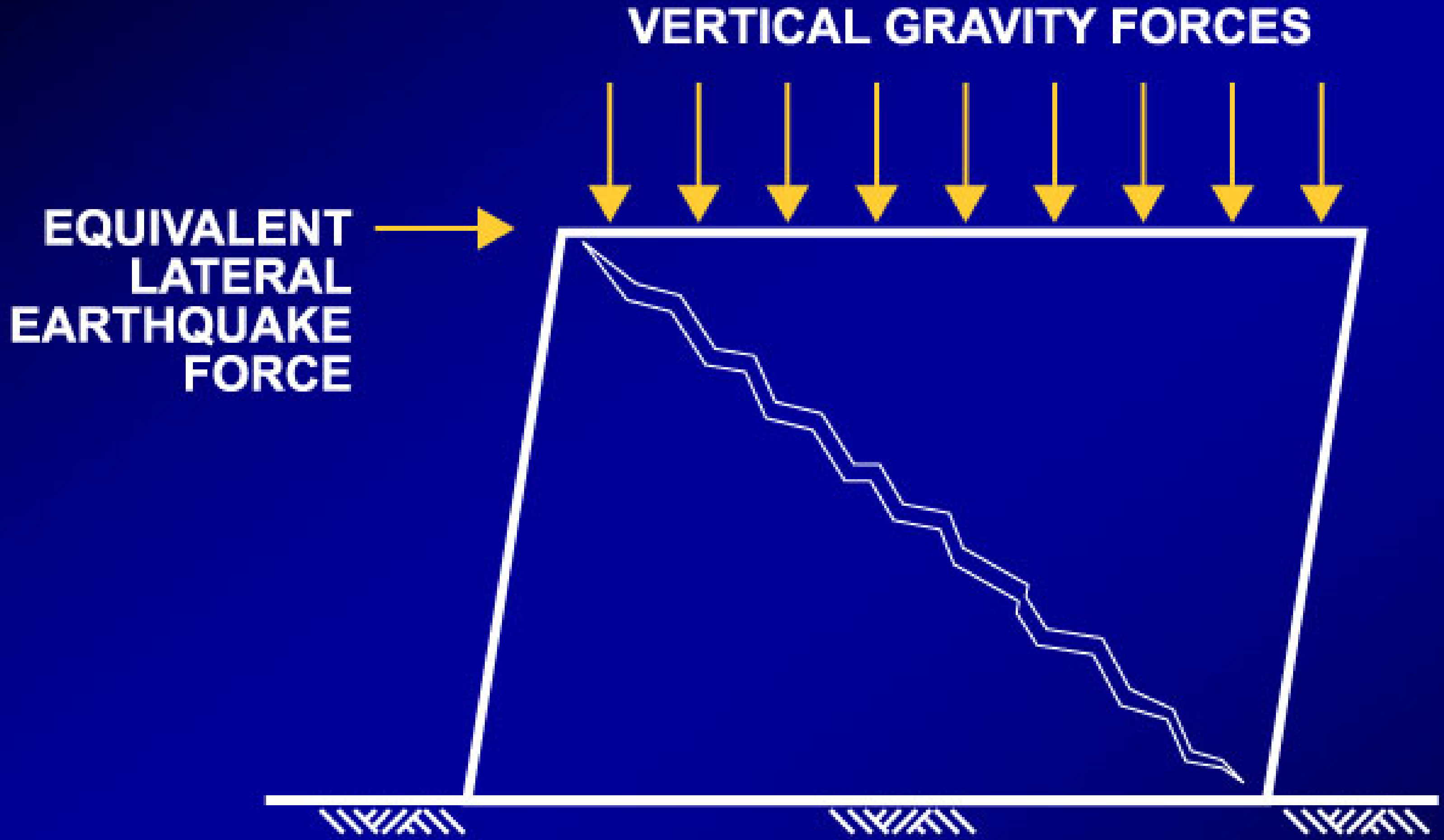
WEIGHT
INERTIA

STRUCTURAL WALL

EARTHQUAKE MOVEMENT

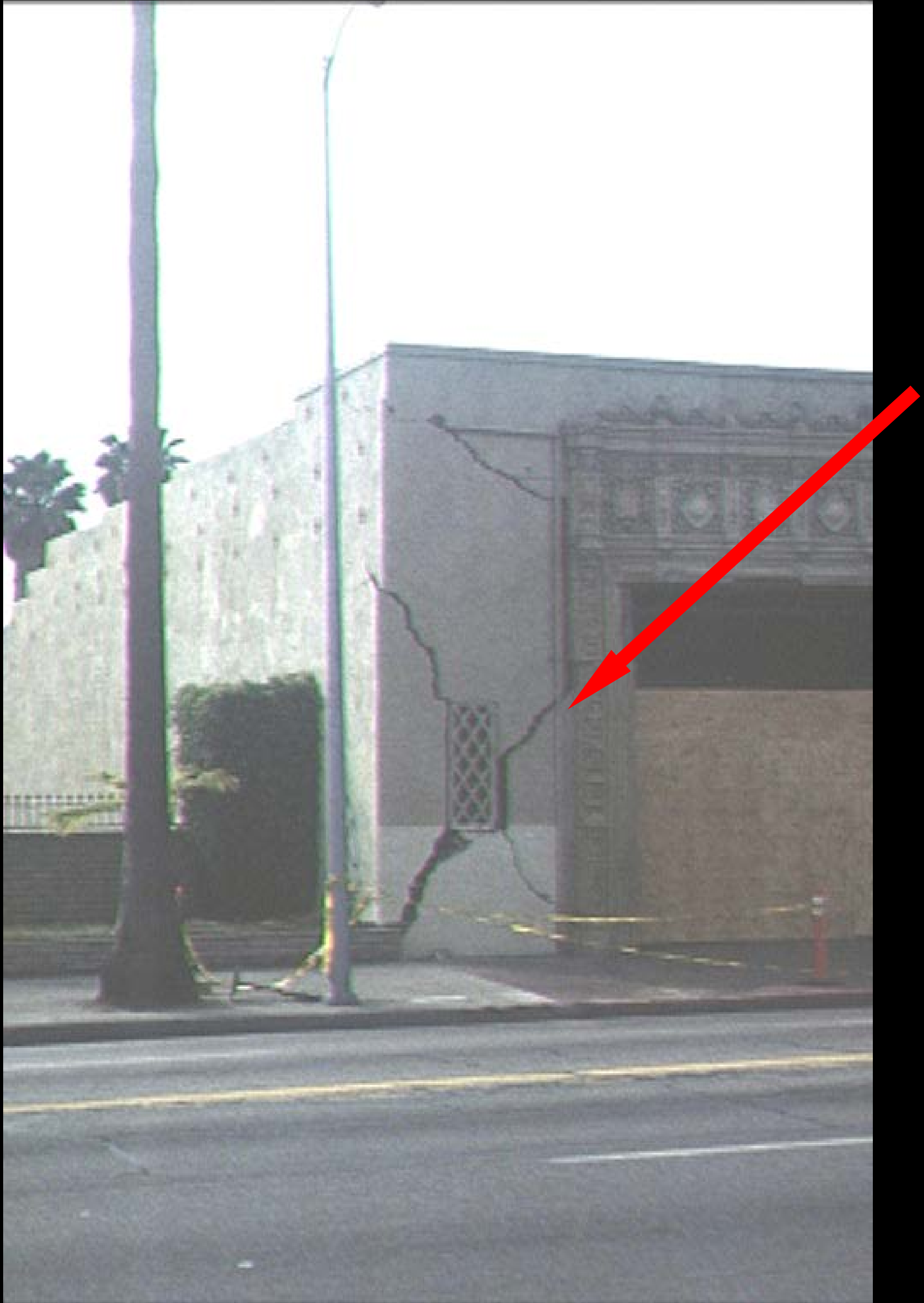

VERTICAL GRAVITY FORCES

EQUIVALENT
LATERAL
EARTHQUAKE
FORCE

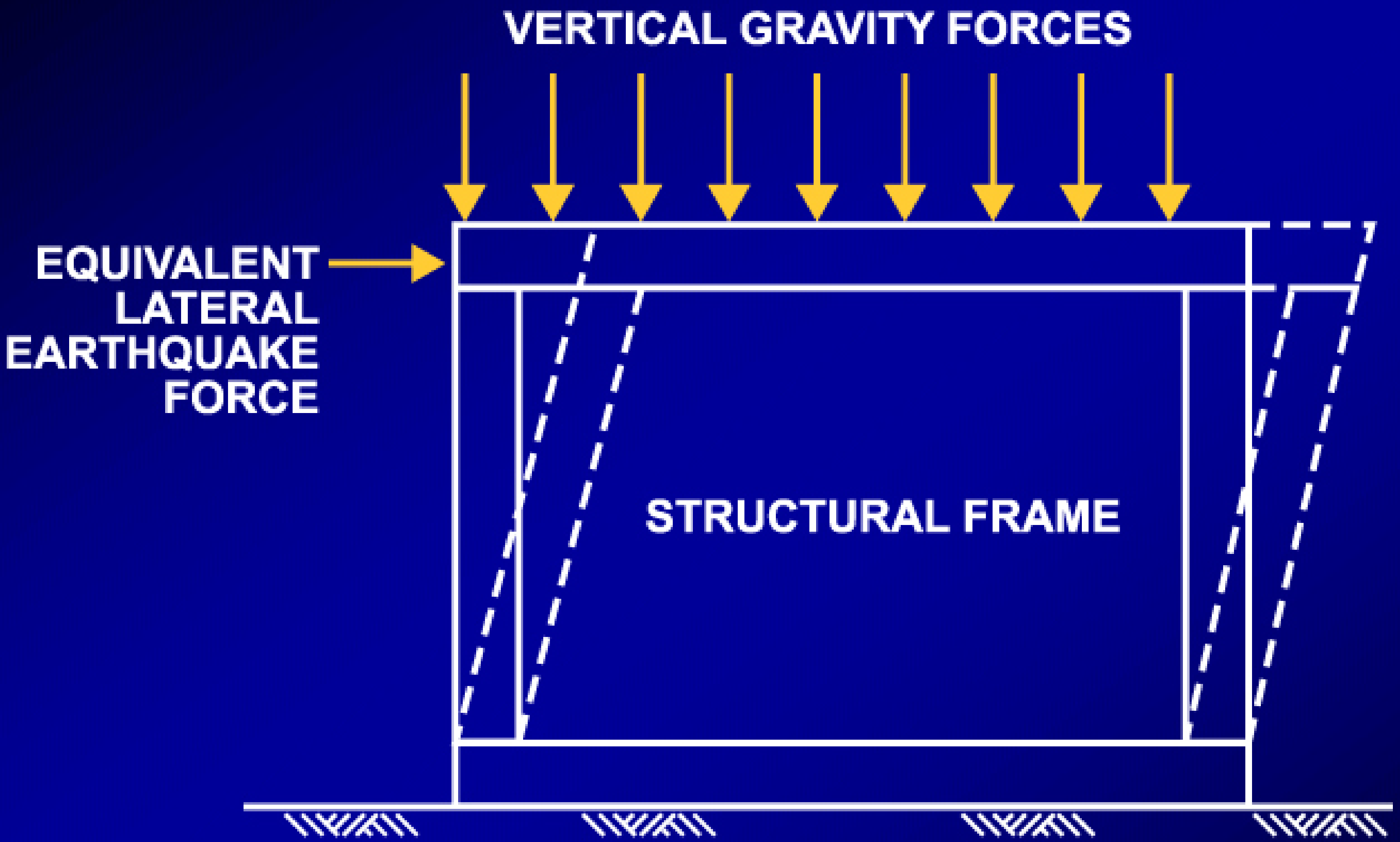


VERTICAL GRAVITY FORCES

EQUIVALENT
LATERAL
EARTHQUAKE
FORCE



DIAGONAL CRACKING

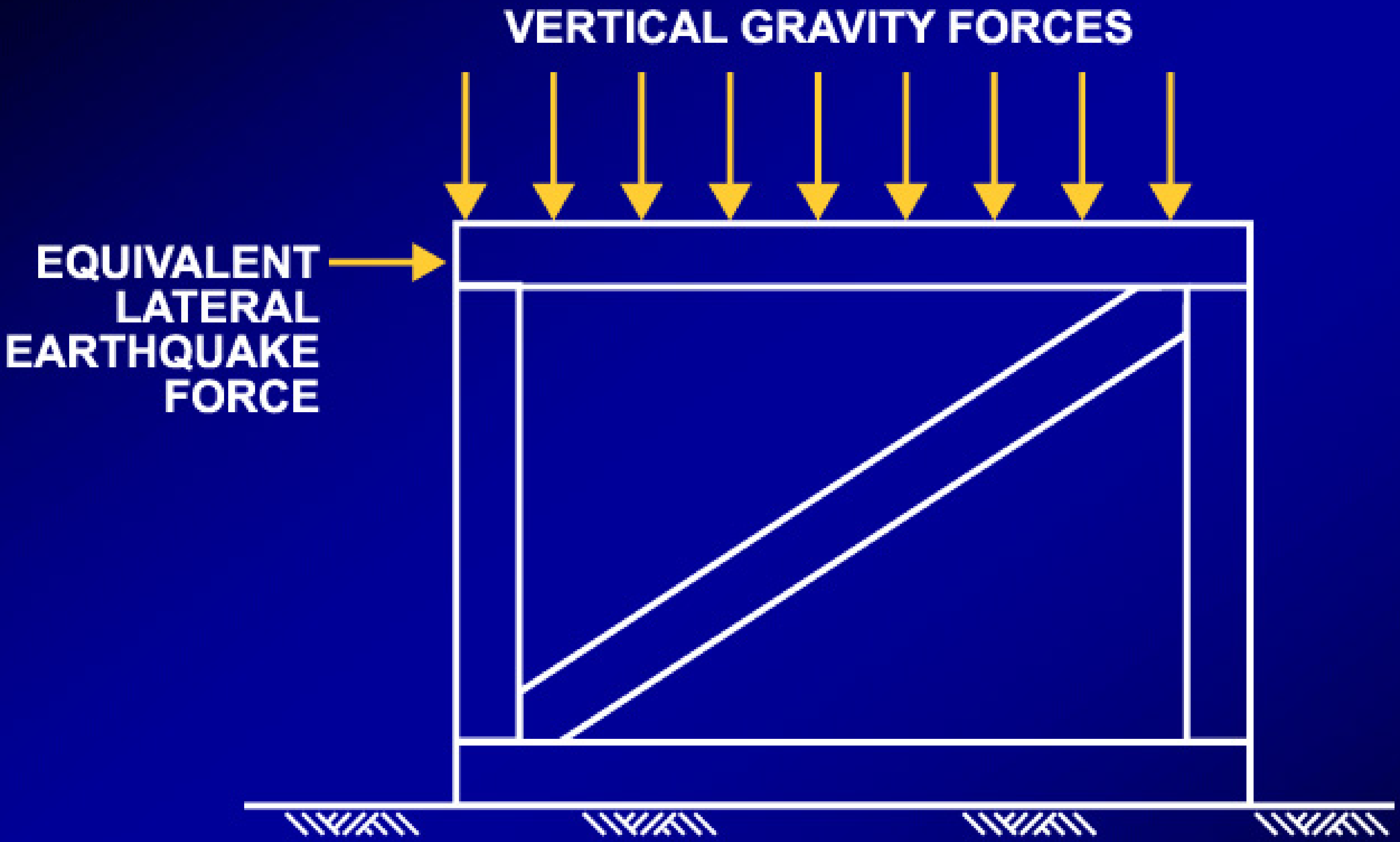


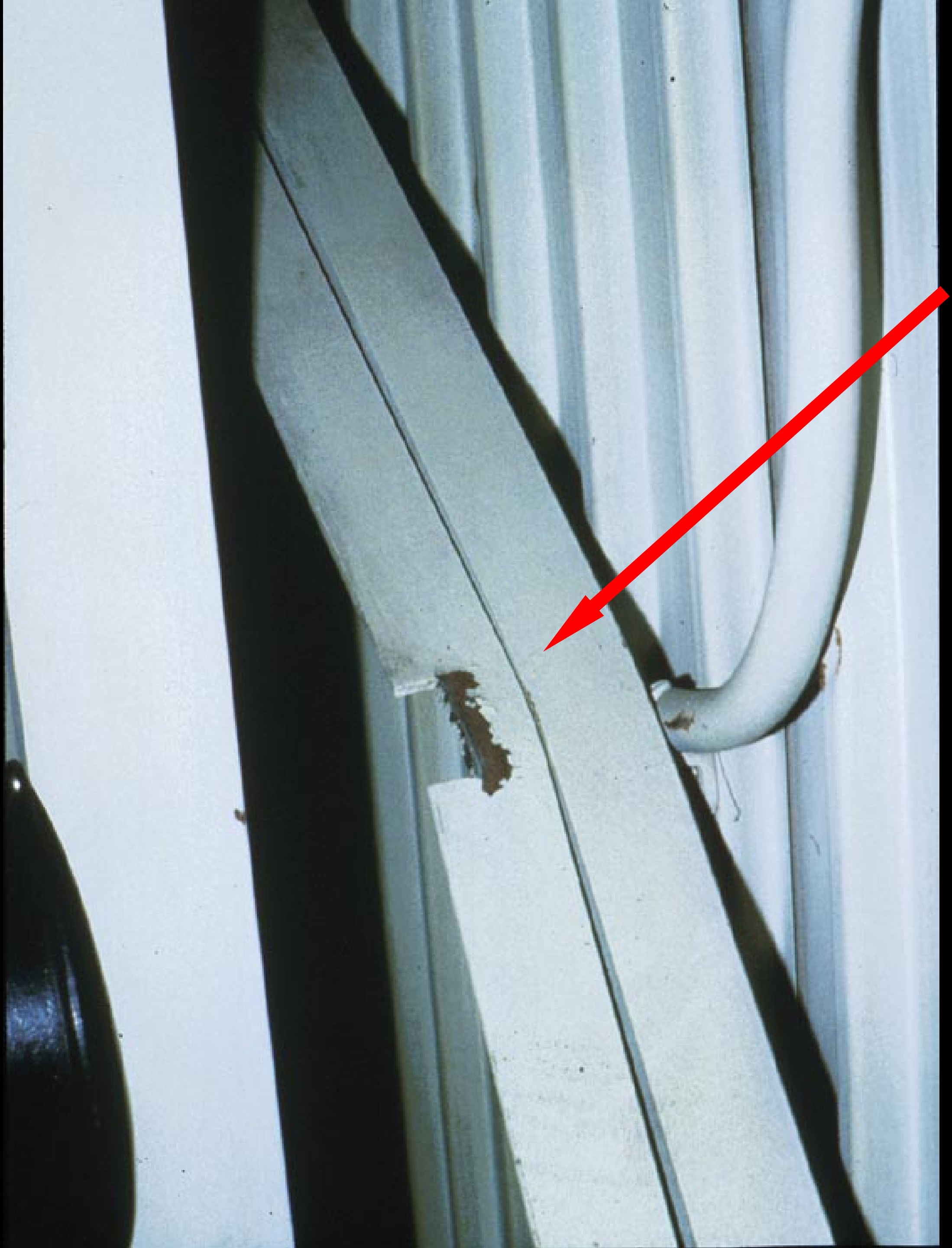
VERTICAL GRAVITY FORCES

EQUIVALENT
LATERAL
EARTHQUAKE
FORCE

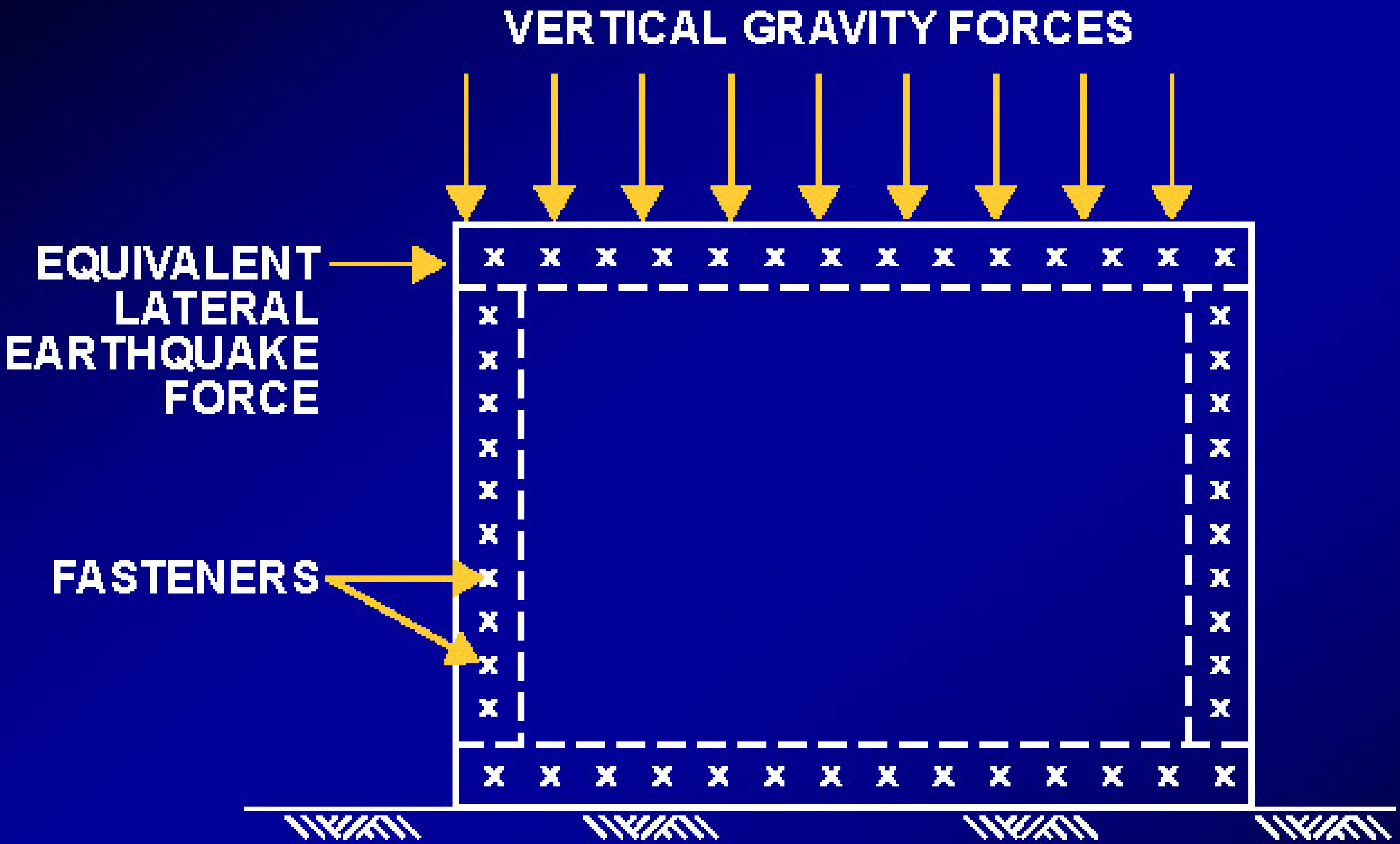
STRUCTURAL FRAME

DIAGONALLY BRACED FRAME





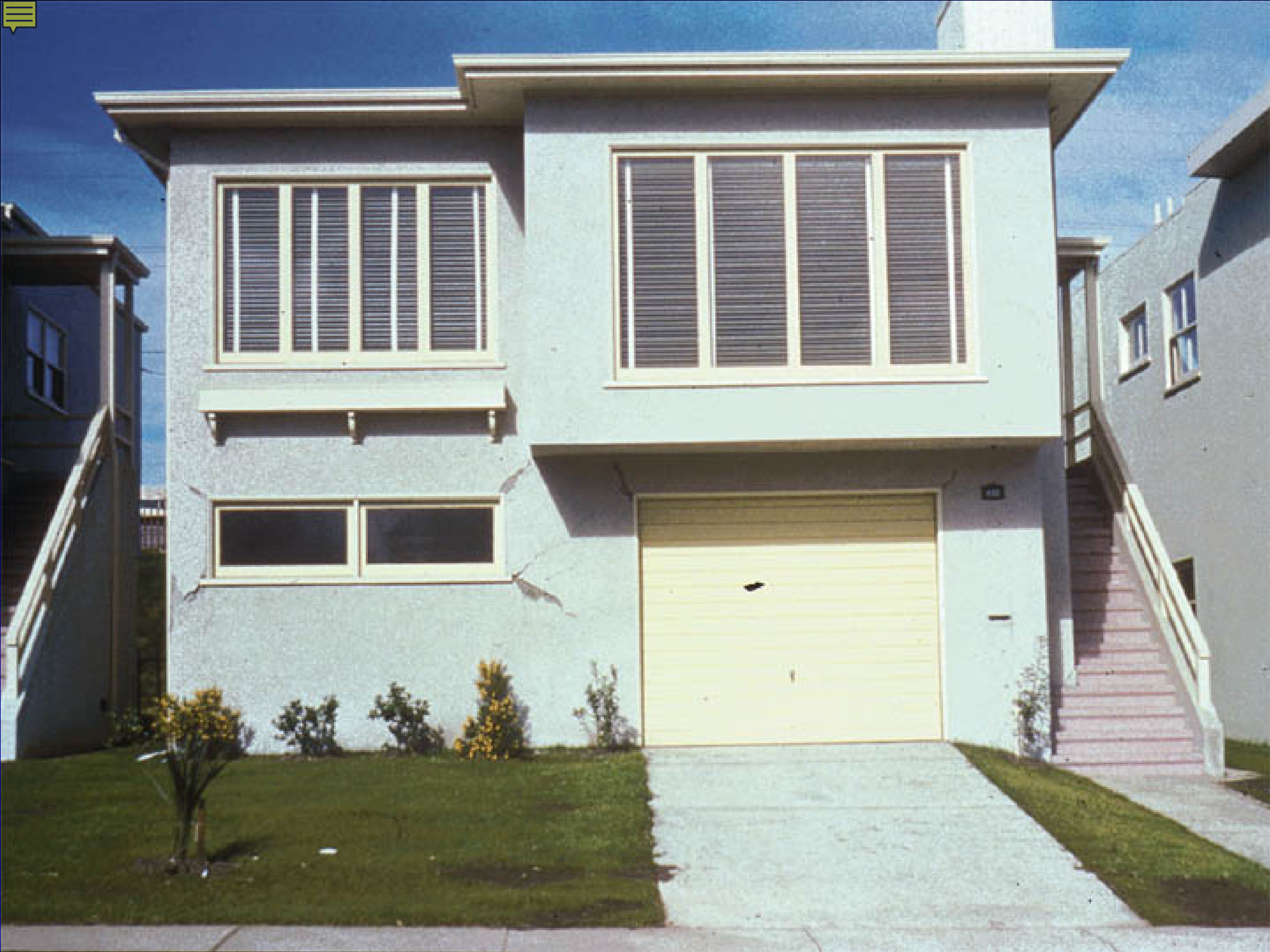
BUCKLED STEEL DIAGONAL MEMBER – LOSS OF STIFFNESS



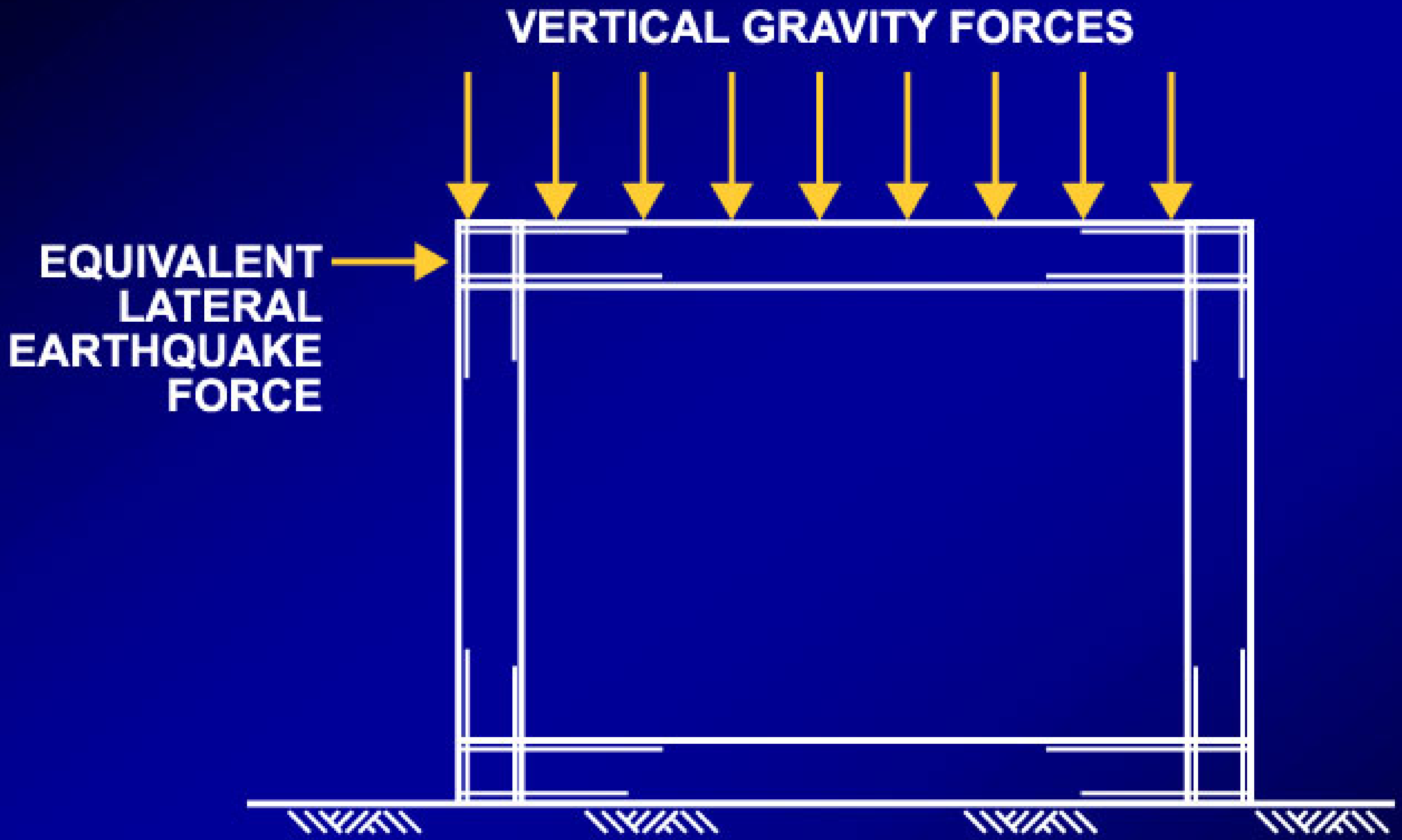
VERTICAL GRAVITY FORCES

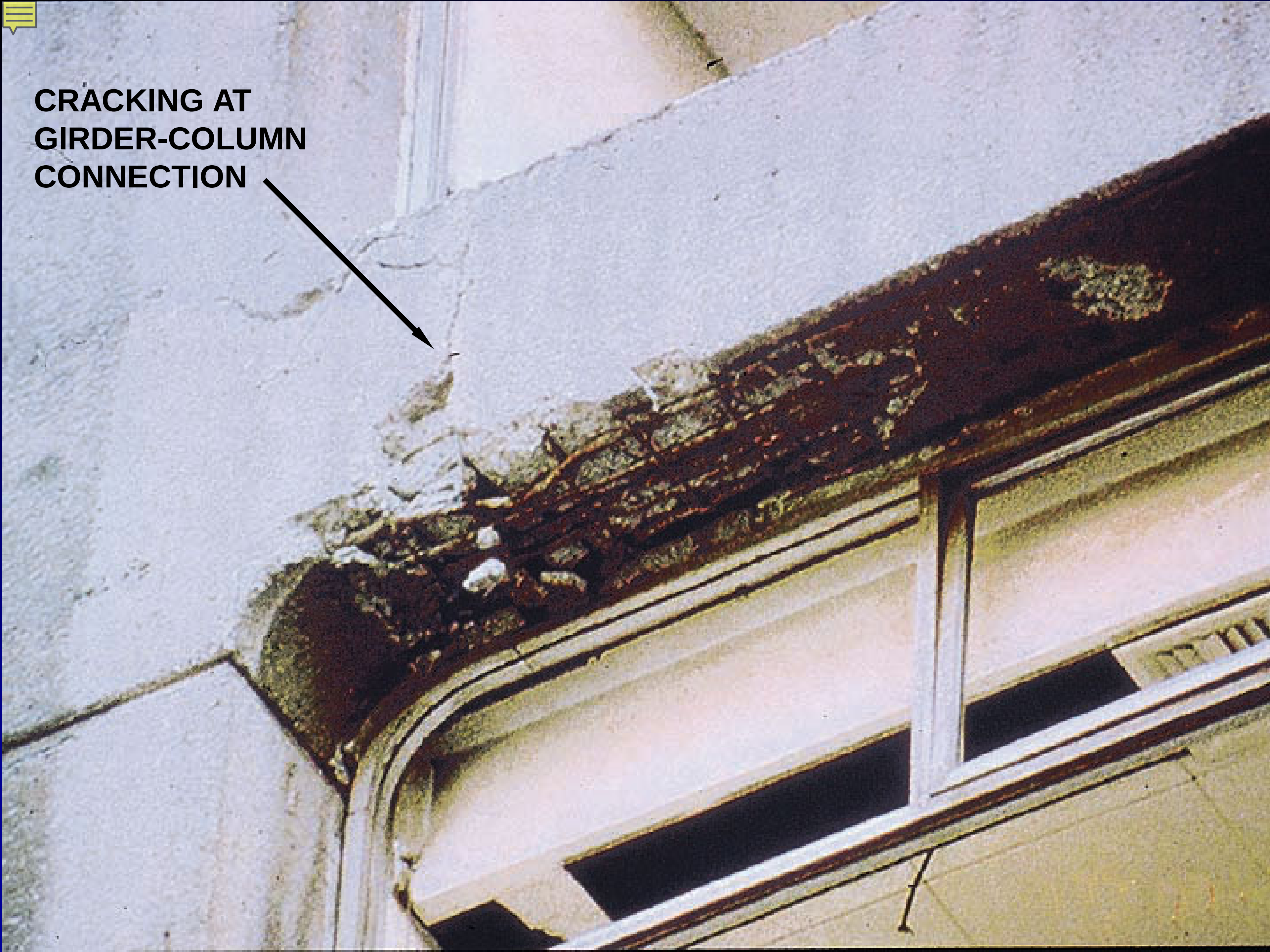
EQUIVALENT
LATERAL
EARTHQUAKE
FORCE

FASTENERS

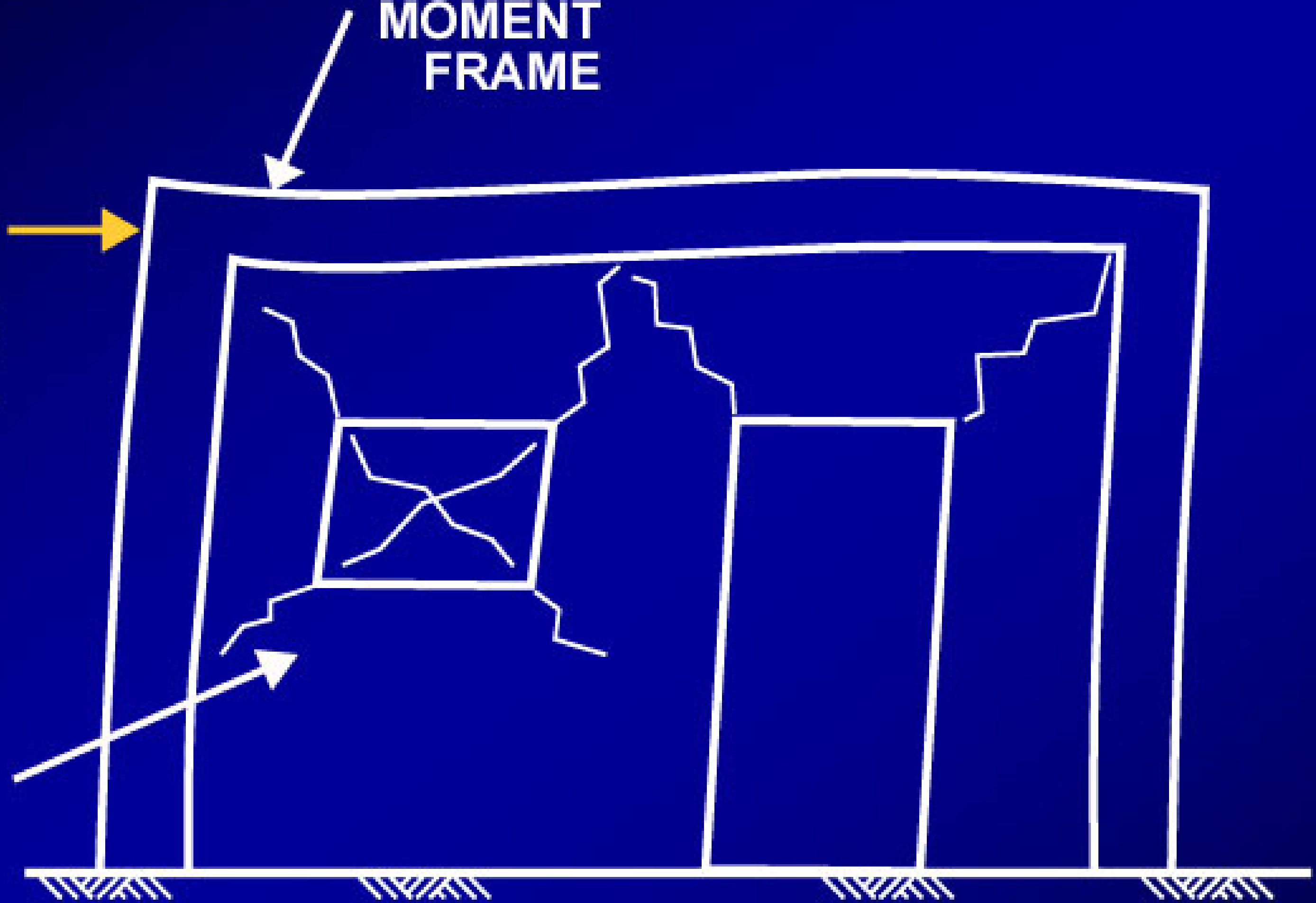


MOMENT-RESISTING FRAME





CRACKING AT GIRDER-COLUMN CONNECTION

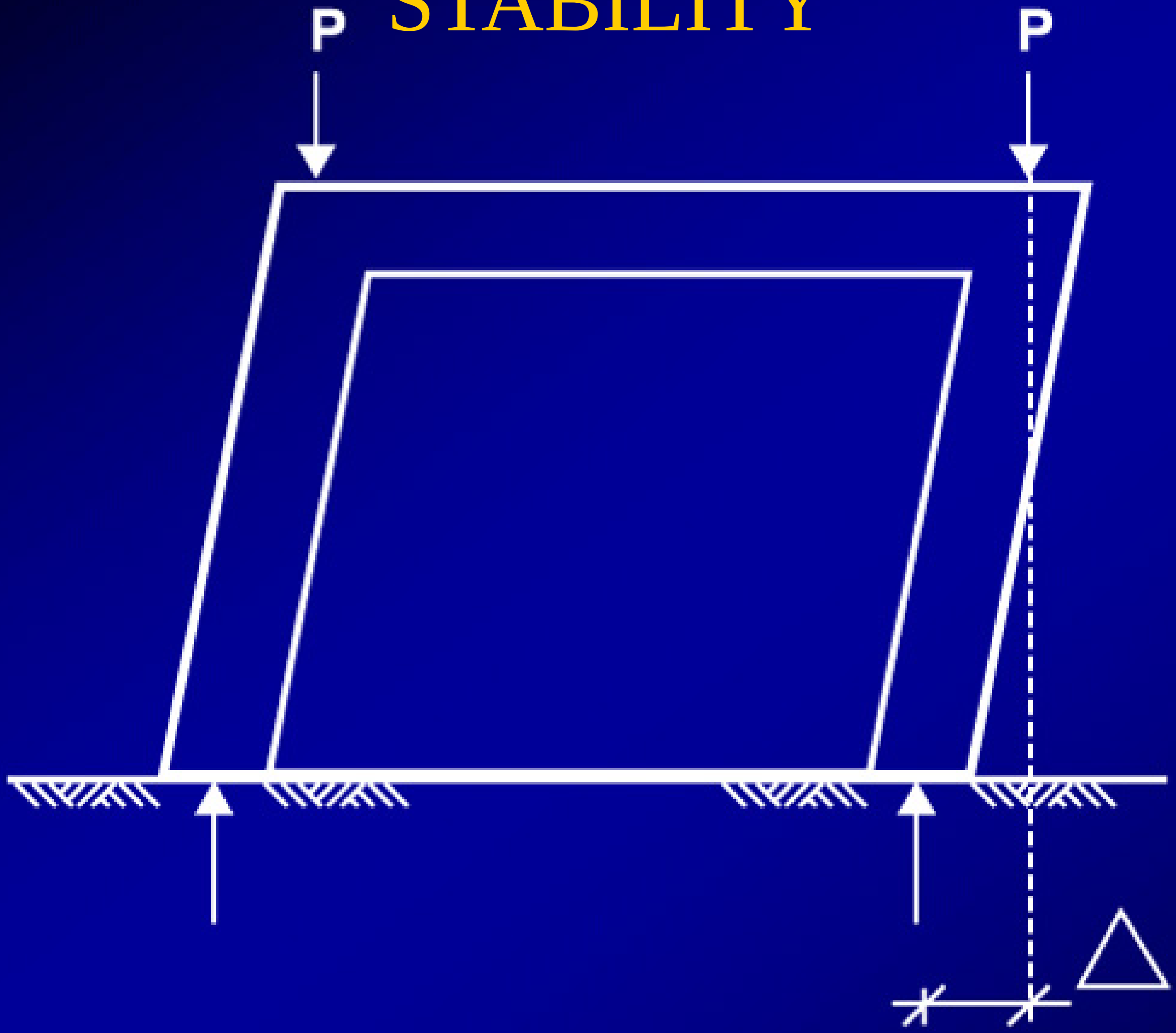


FLEXIBLE
MOMENT
FRAME

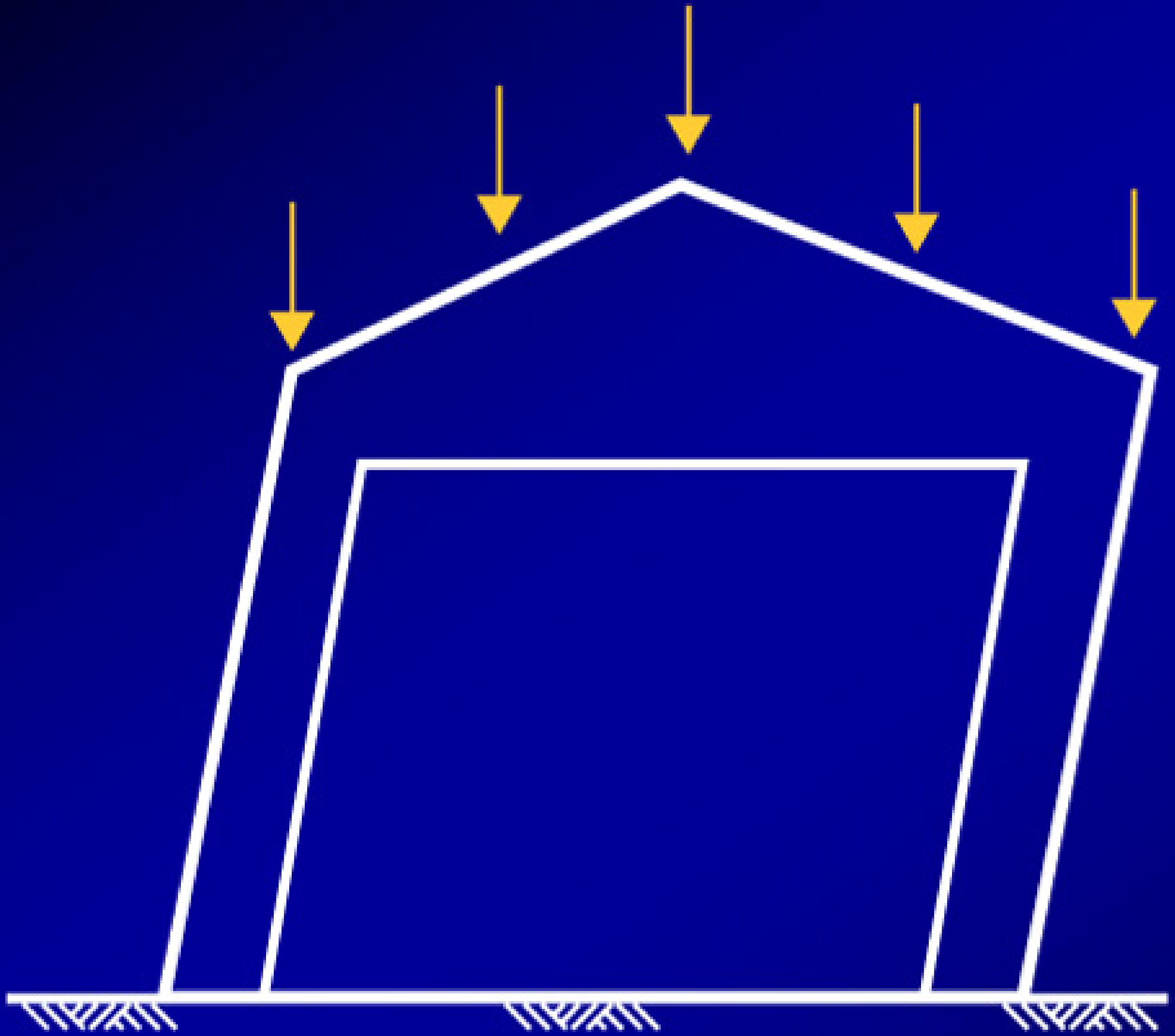
EQUIVALENT
LATERAL
EARTHQUAKE
FORCE

BRITTLE
SHEATHING

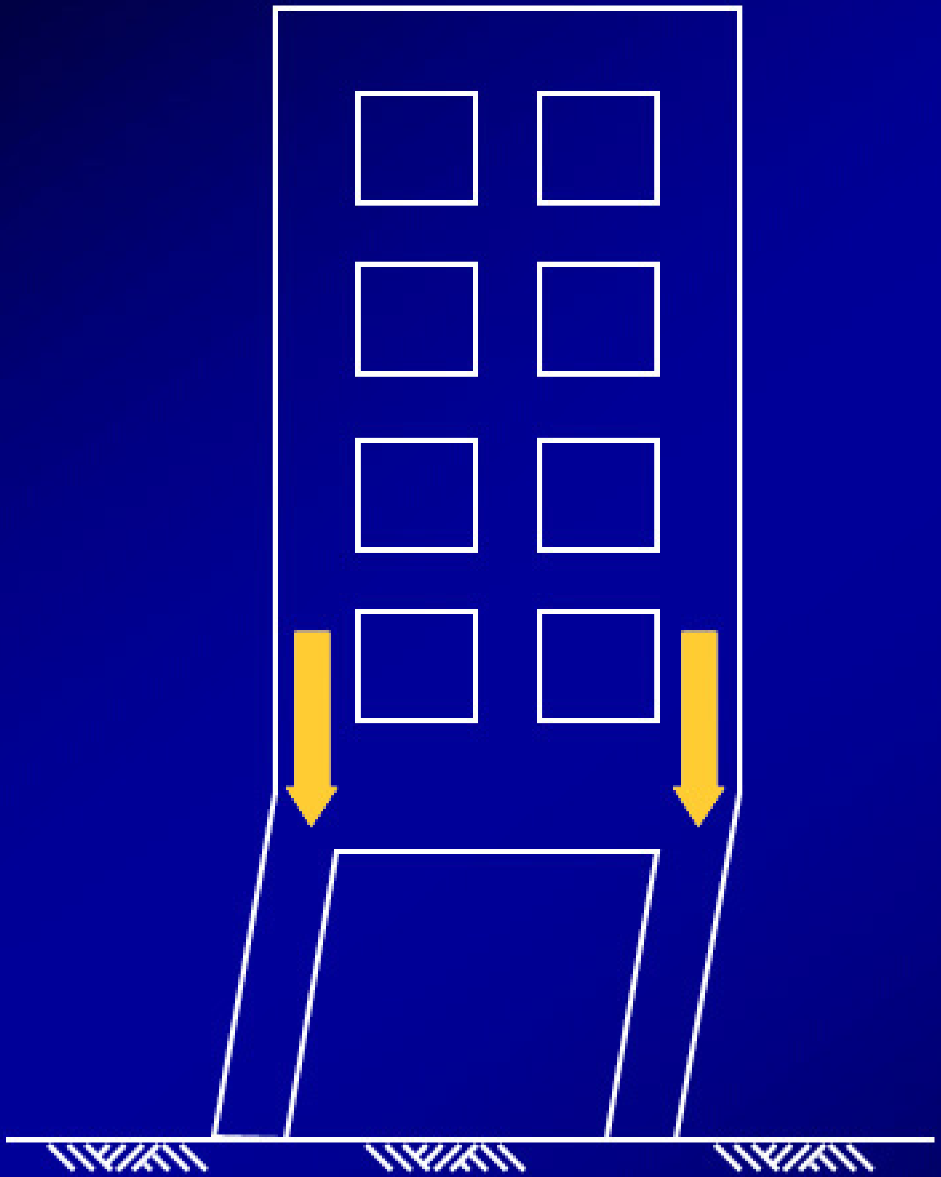
STABILITY



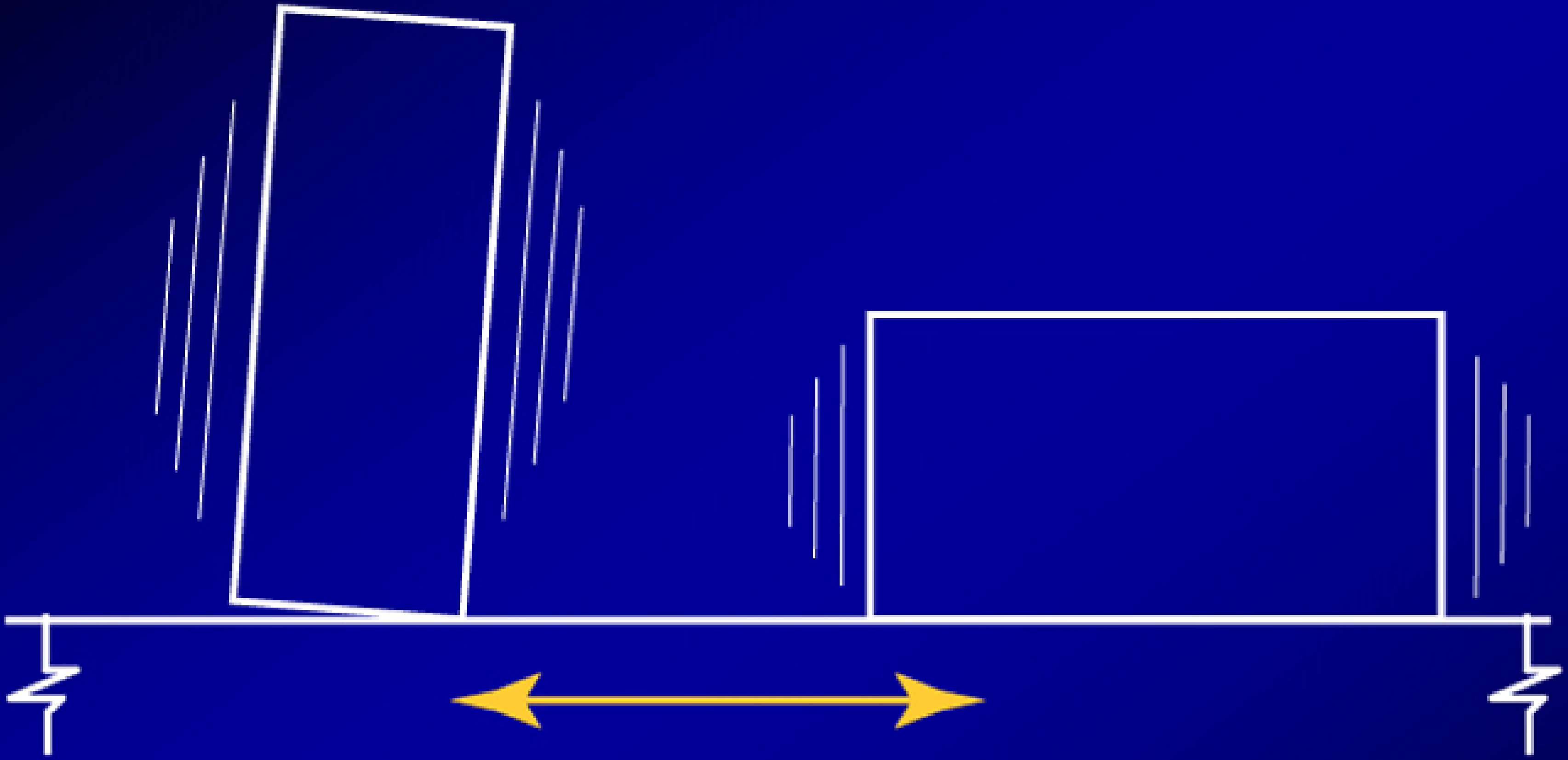
P - DELTA EFFECT ON RECTANGULAR FRAME



SMALL P-DELTA LOADS IN A GARAGE

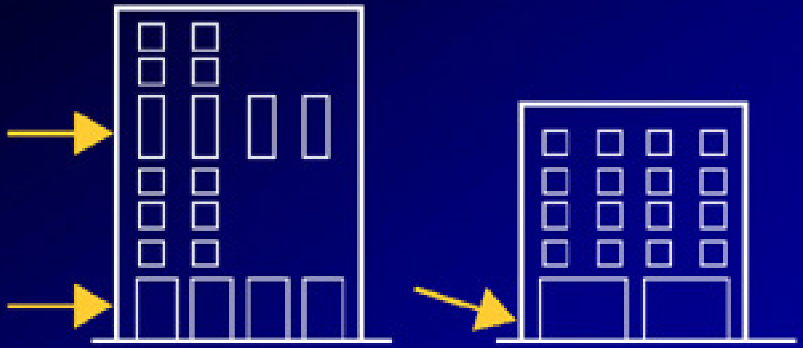


LARGE P-DELTA LOADS IN MULTI-STORY BUILDING

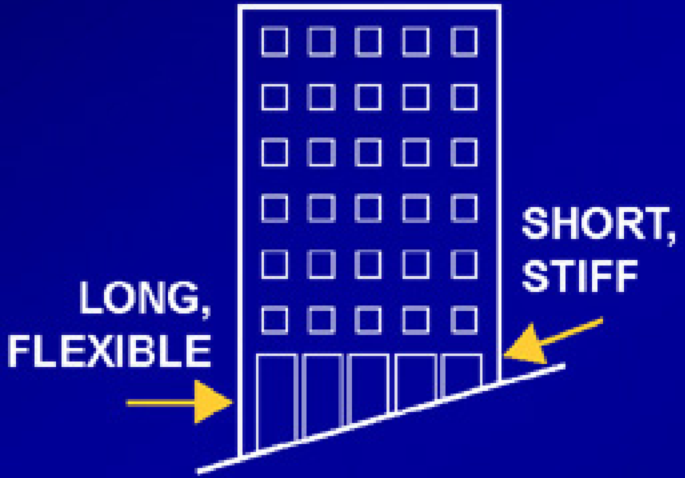


OVERTURNING
OF TALL OBJECT

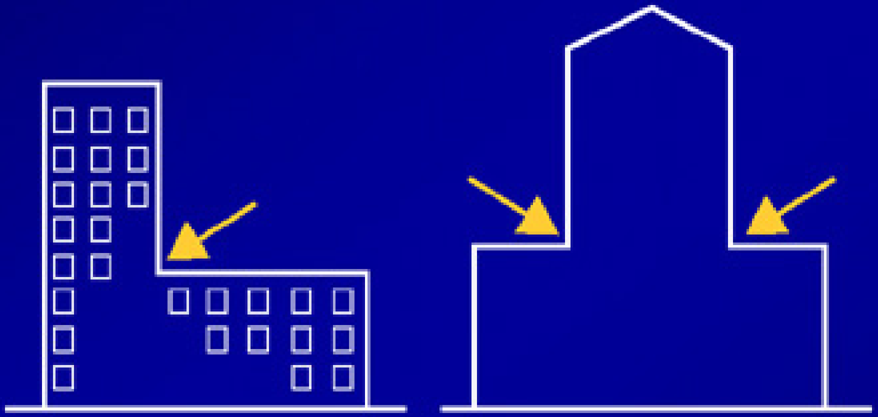
SLIDING
OF LOW OBJECT



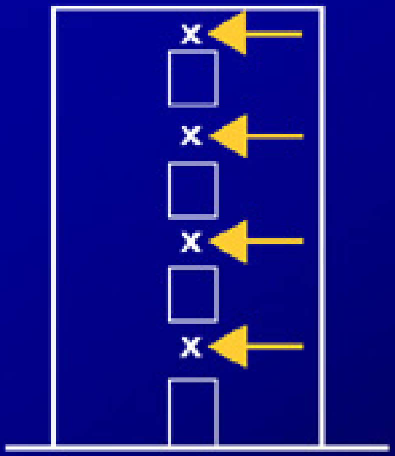
SOFT STORIES



HILSIDE BUILDINGS



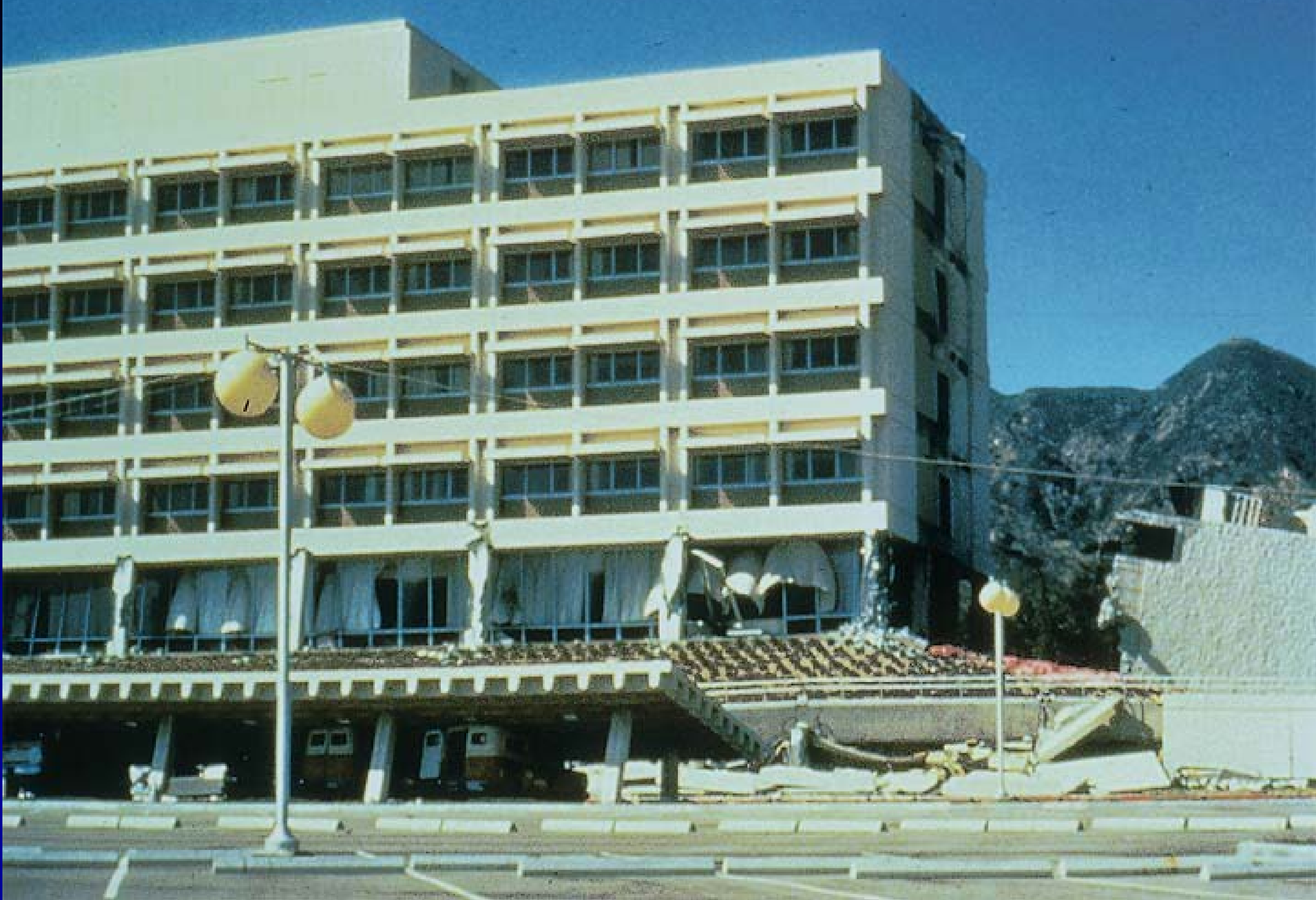
SETBACKS



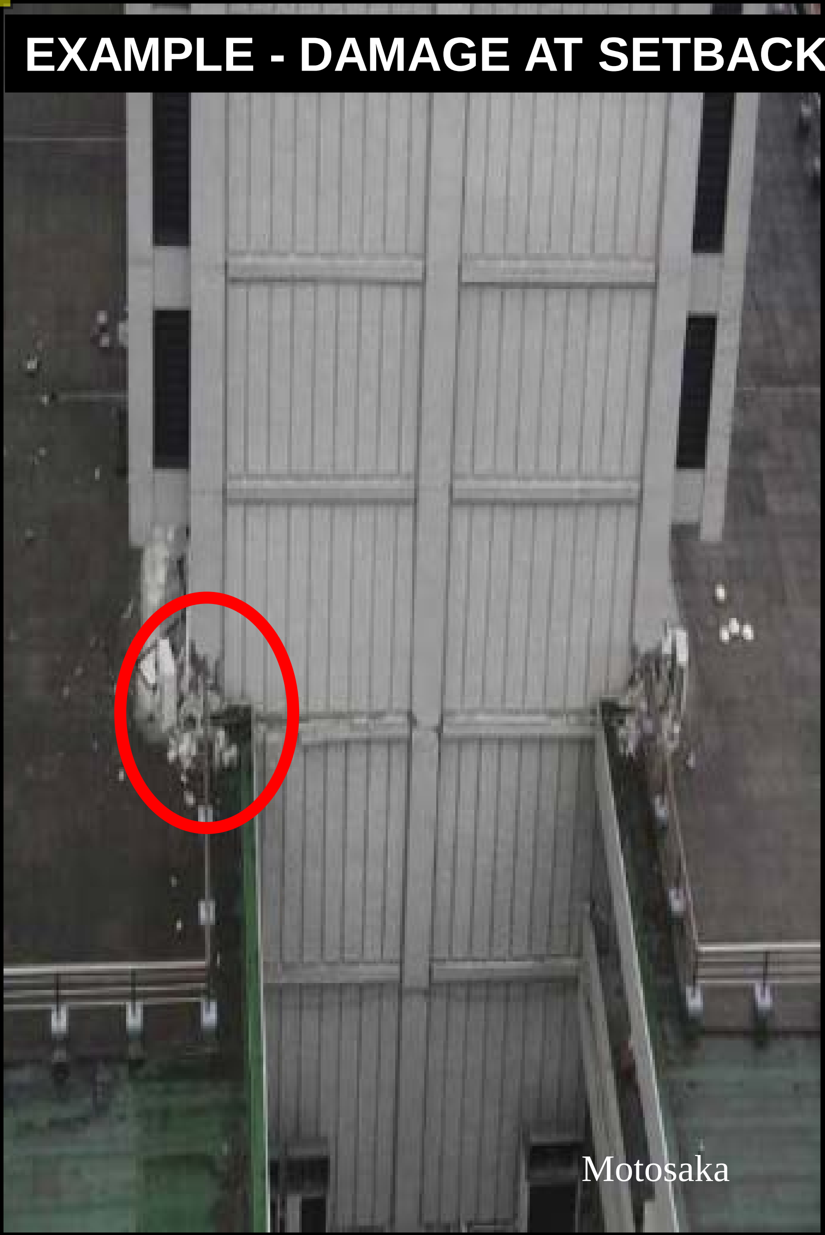
COUPLED SHEAR WALL

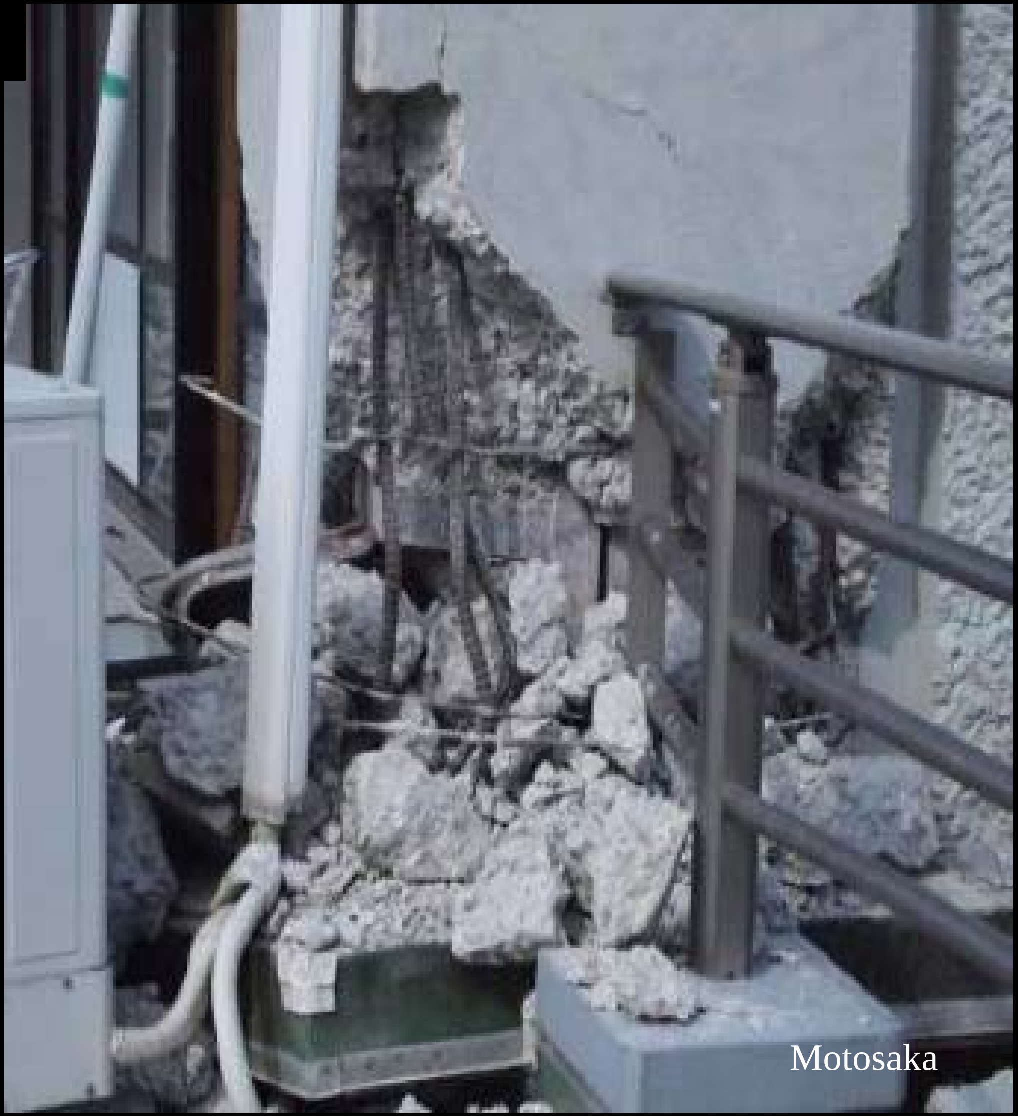
→ AREAS OF PARTICULAR CONCERN

EXAMPLE – SOFT STORY



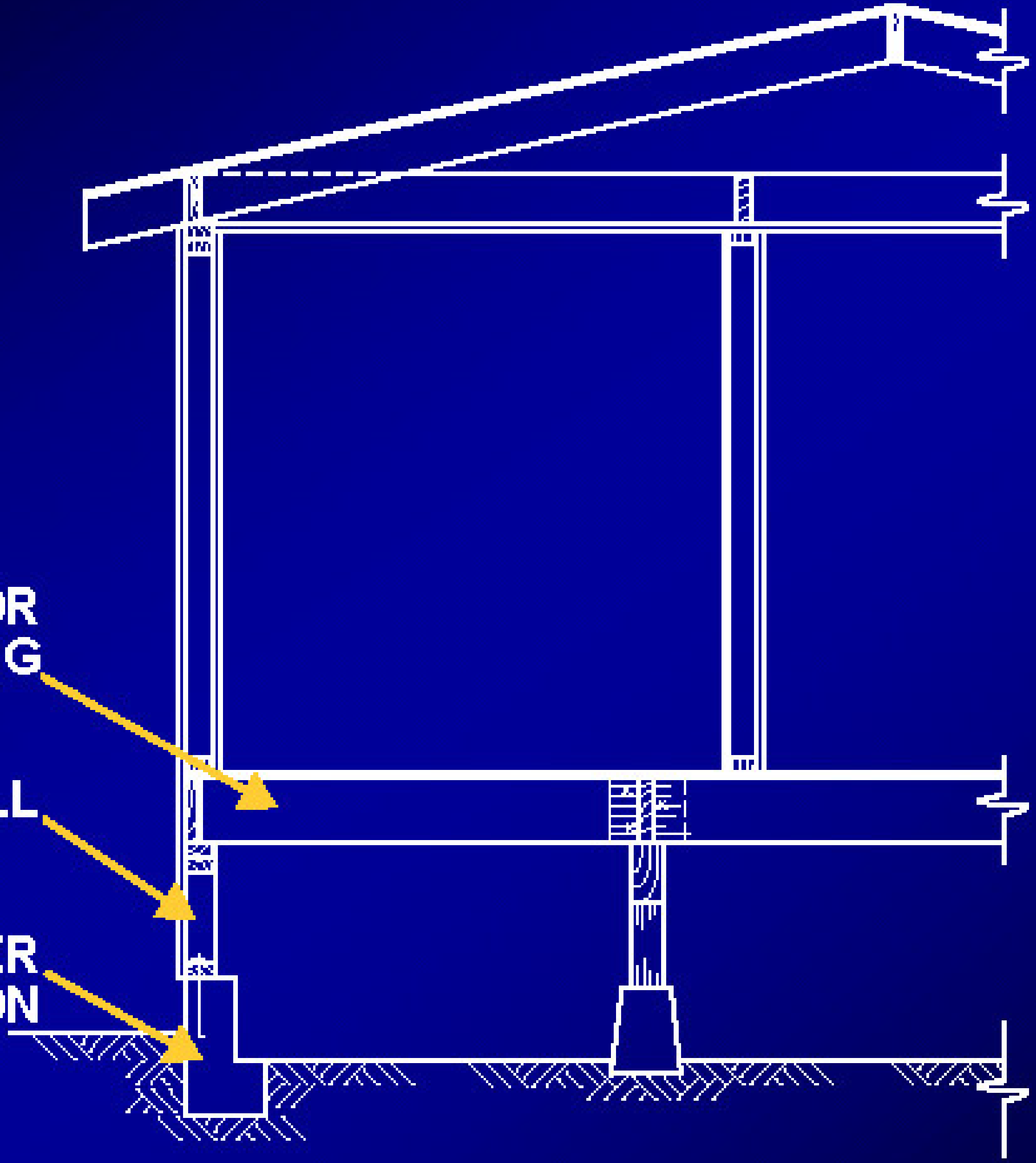
EXAMPLE - DAMAGE AT SETBACK


Motosaka


Motosaka

WOOD-FRAME CONSTRUCTION

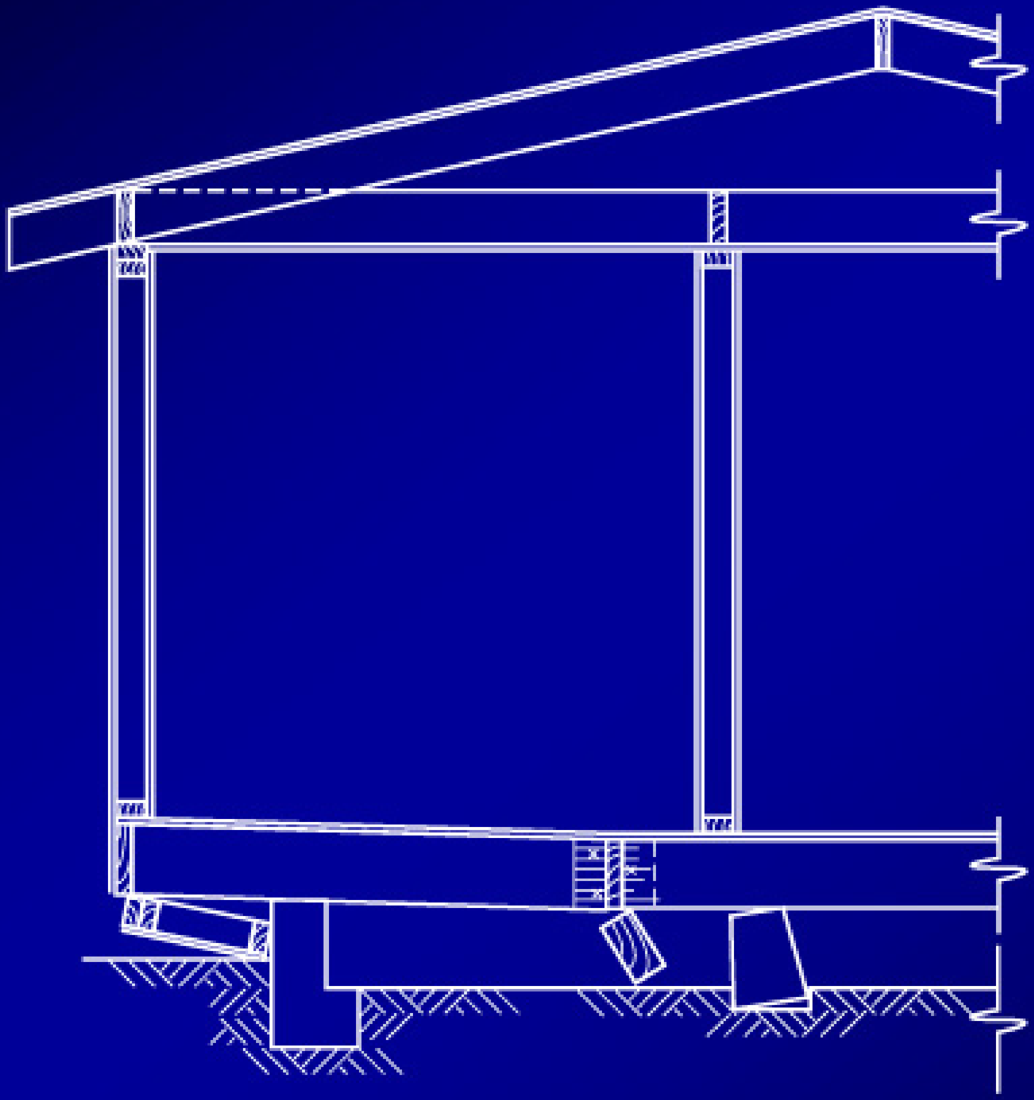
- Single-family residential
- Multi-unit residential and commercial

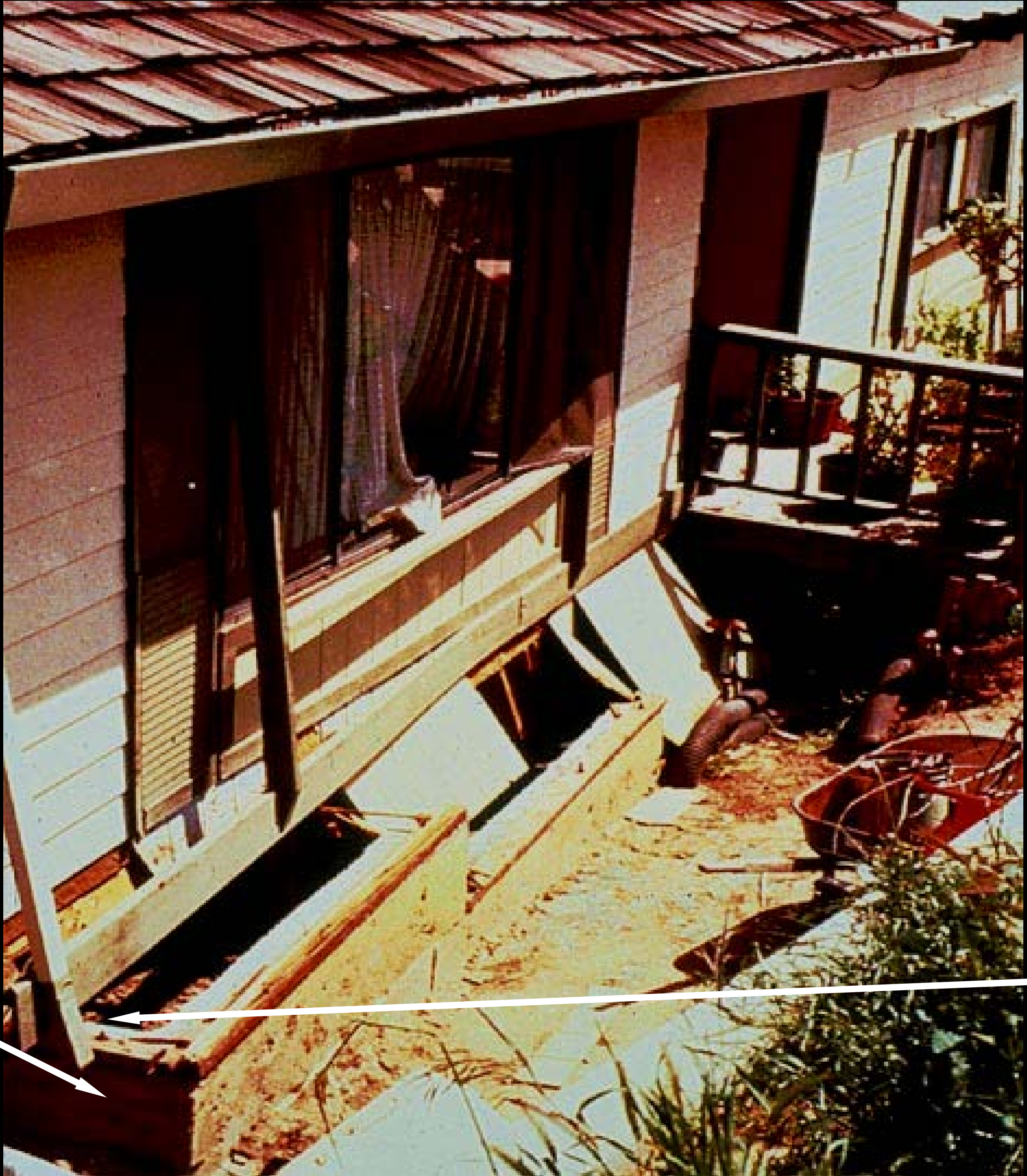


FIRST-FLOOR FRAMING

CRIPPLE WALL

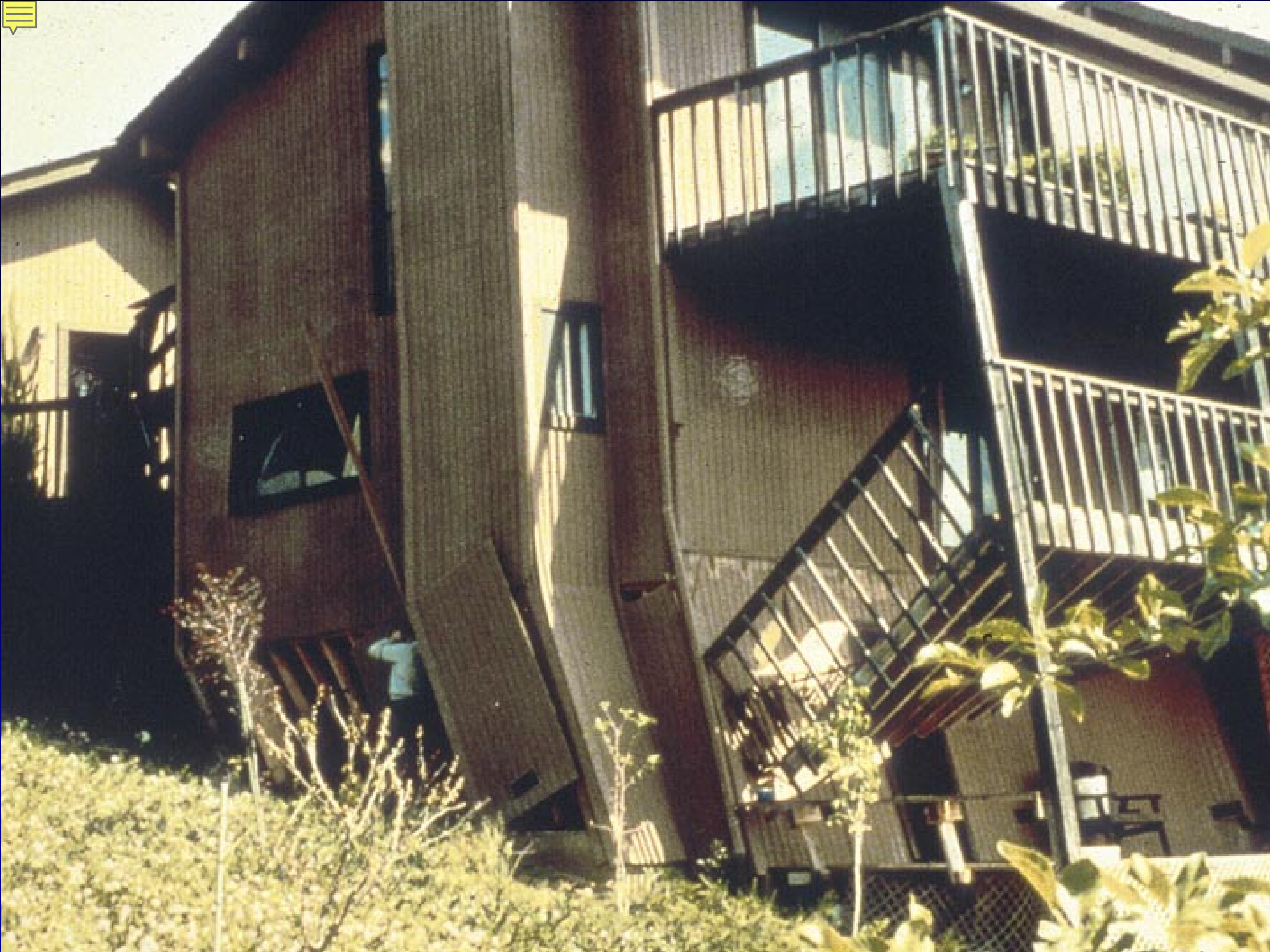
PERIMETER FOUNDATION

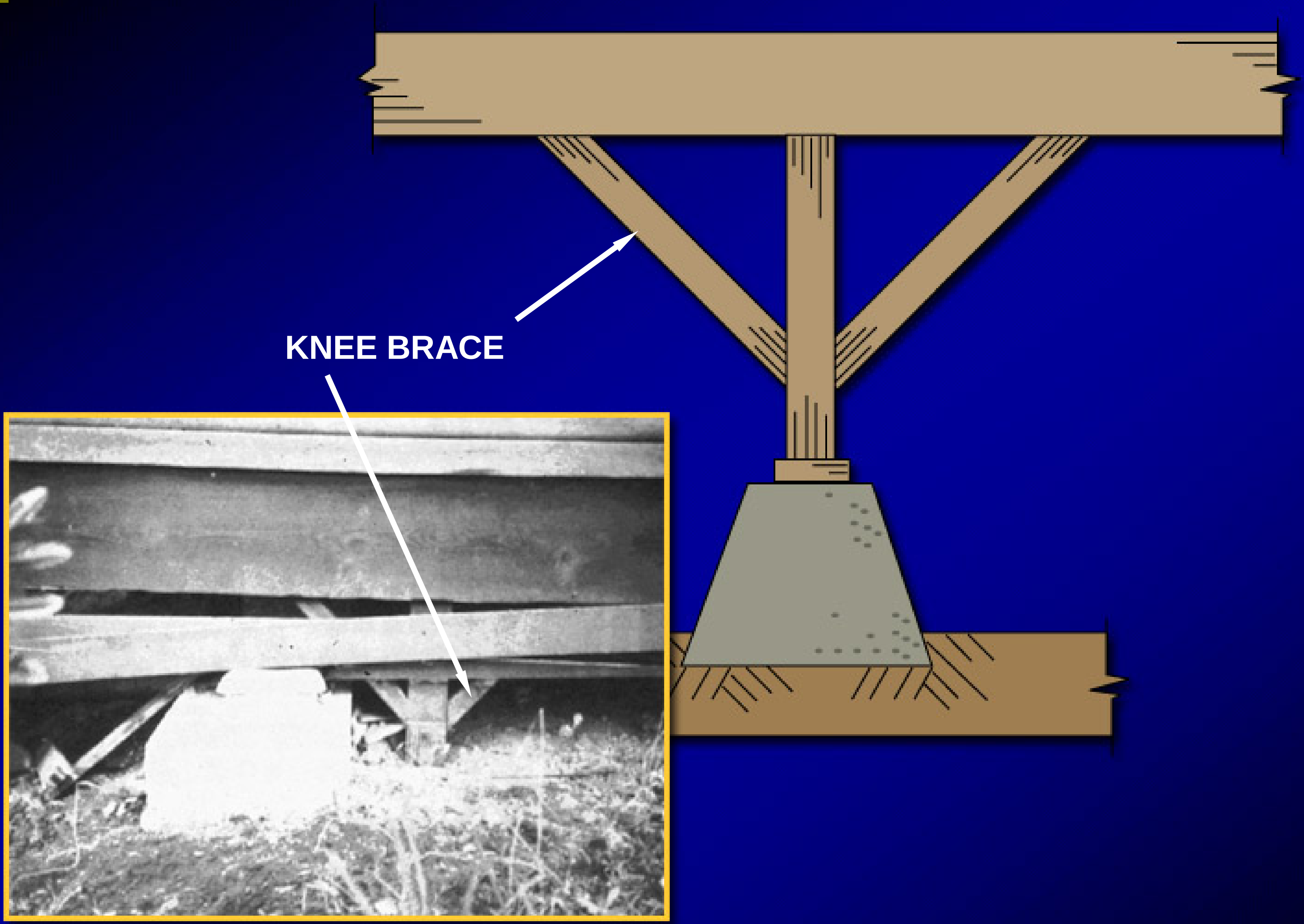




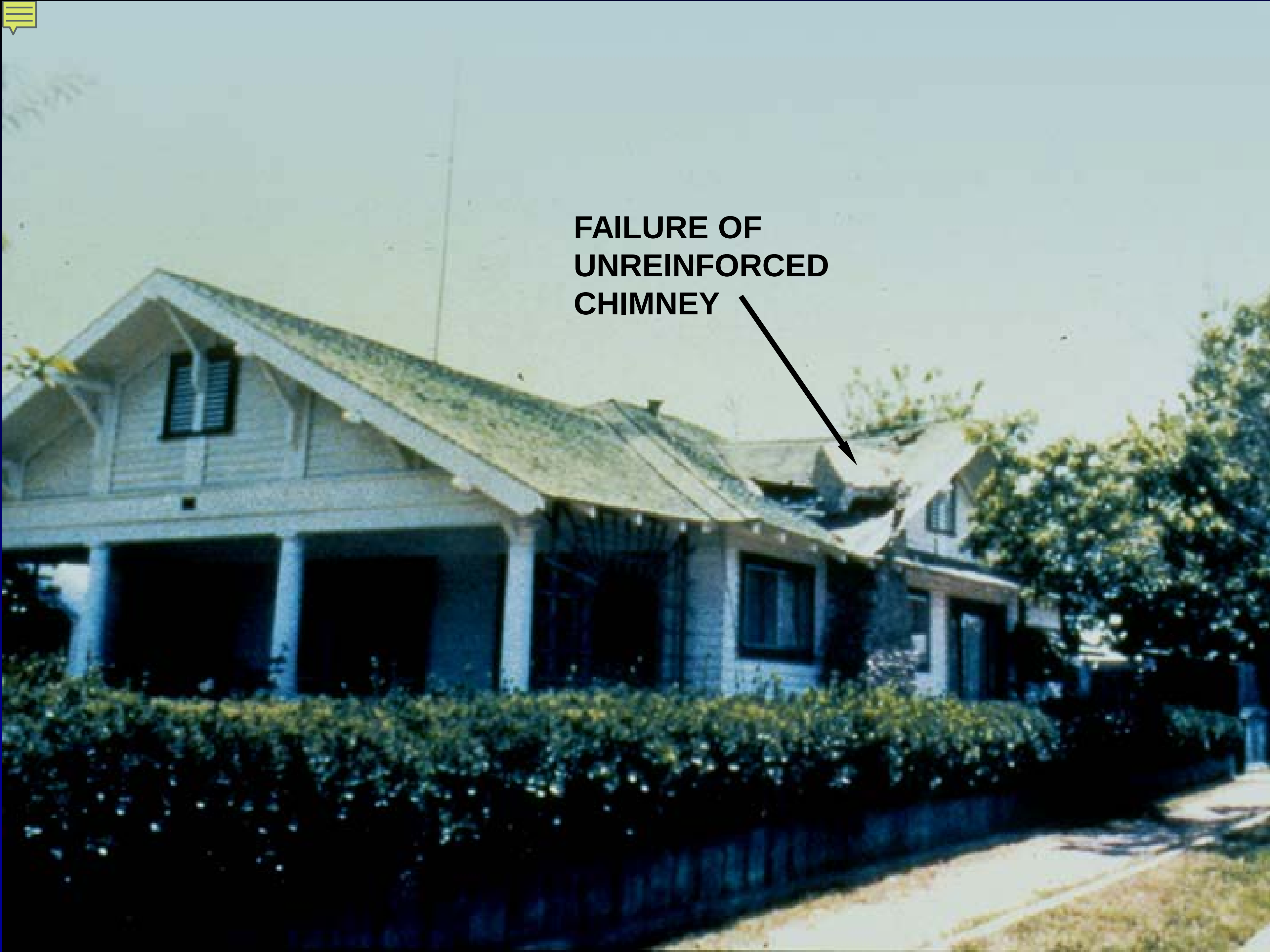
CONCRETE
PERIMETER
WALL
FOUNDATION

FAILED
CRIPPLE
WALL

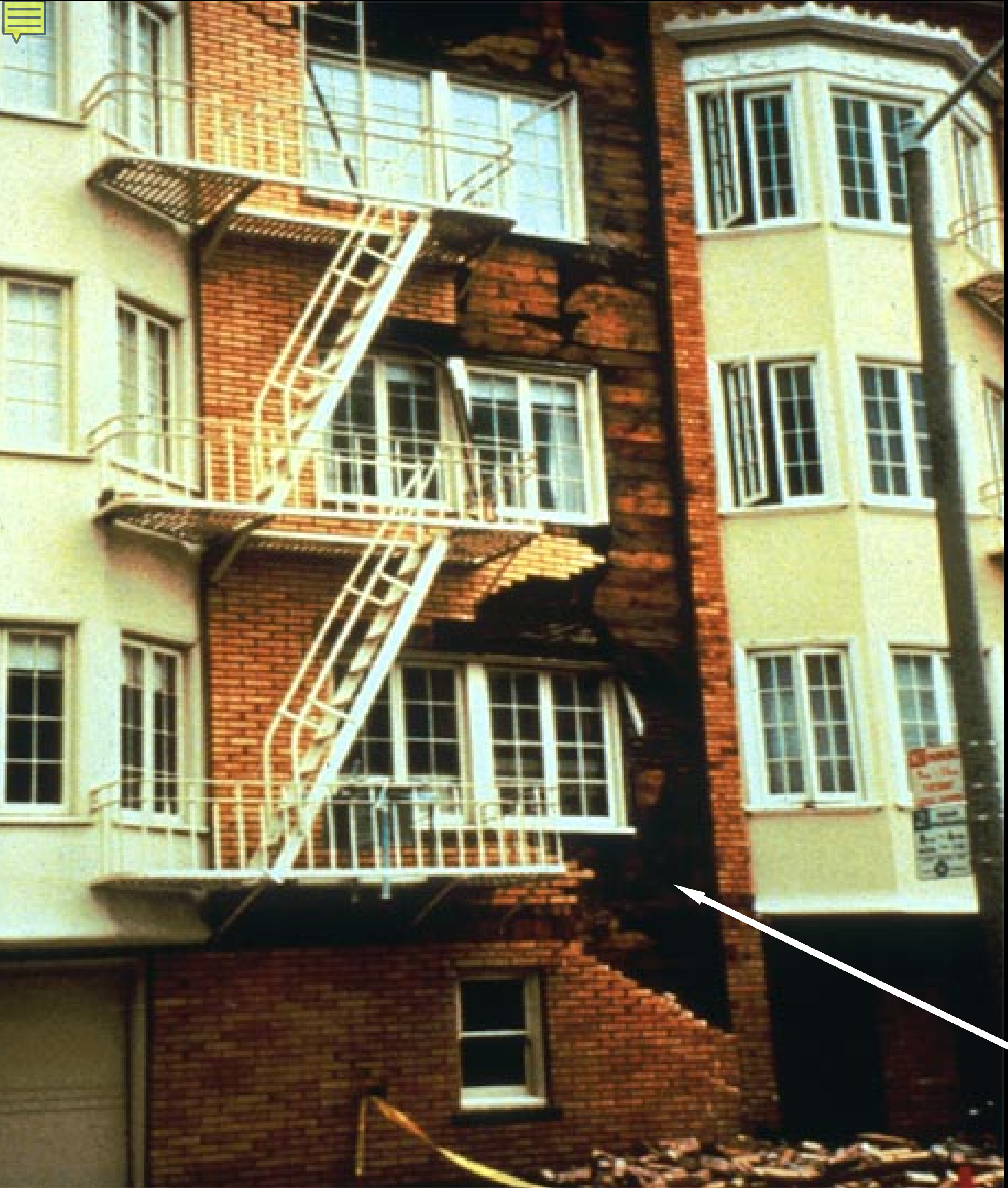




KNEE BRACE



FAILURE OF
UNREINFORCED
CHIMNEY

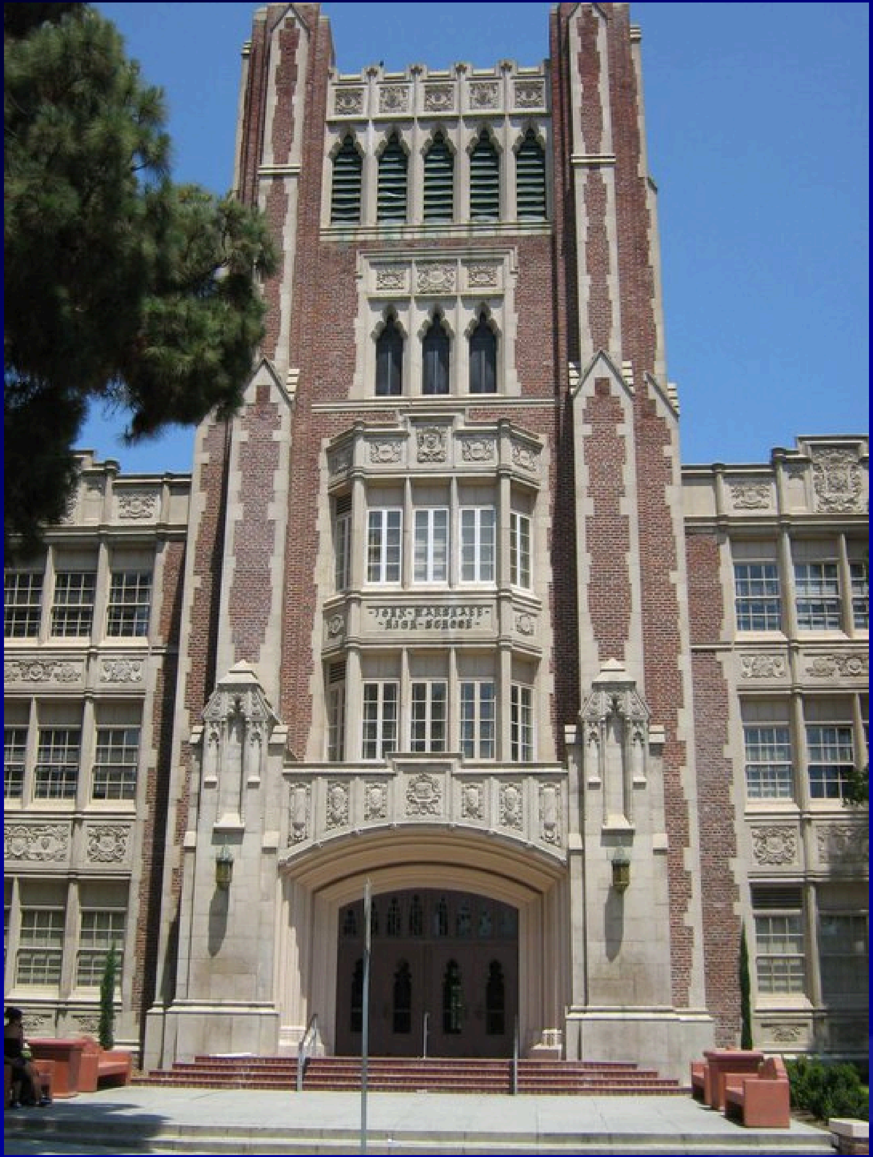


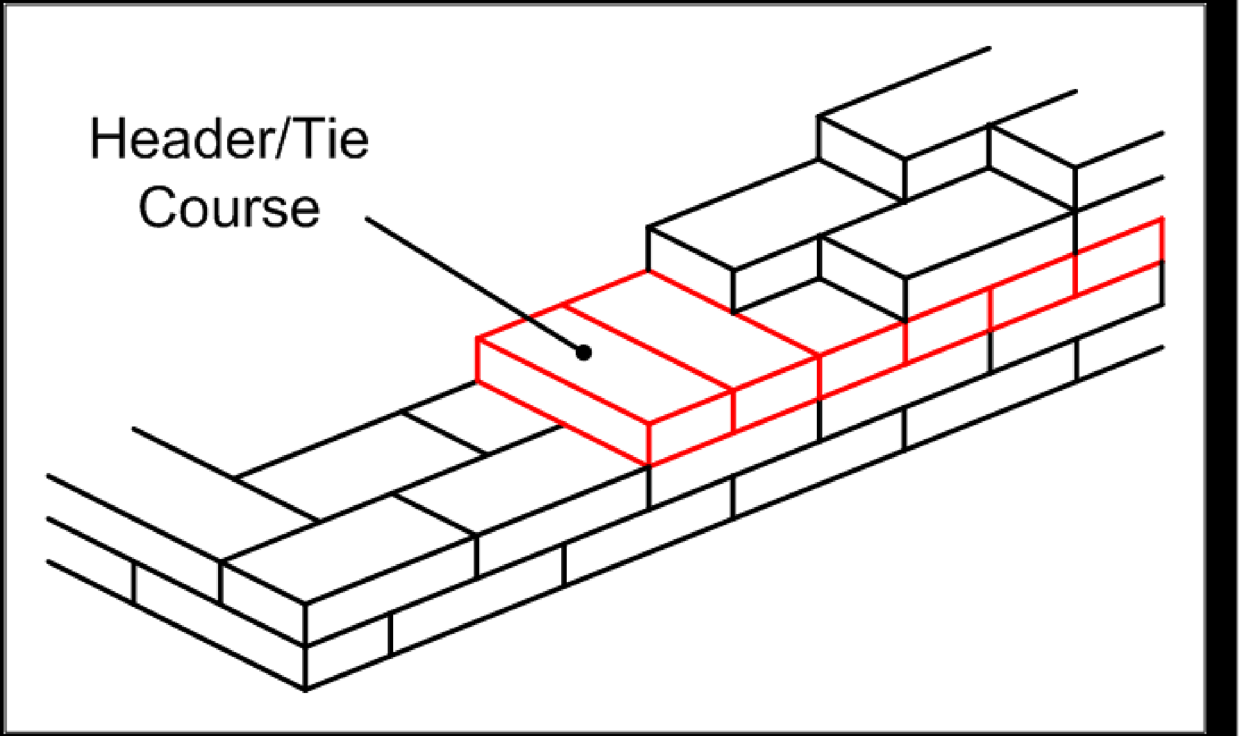
FAILURE OF BRICK VENEER

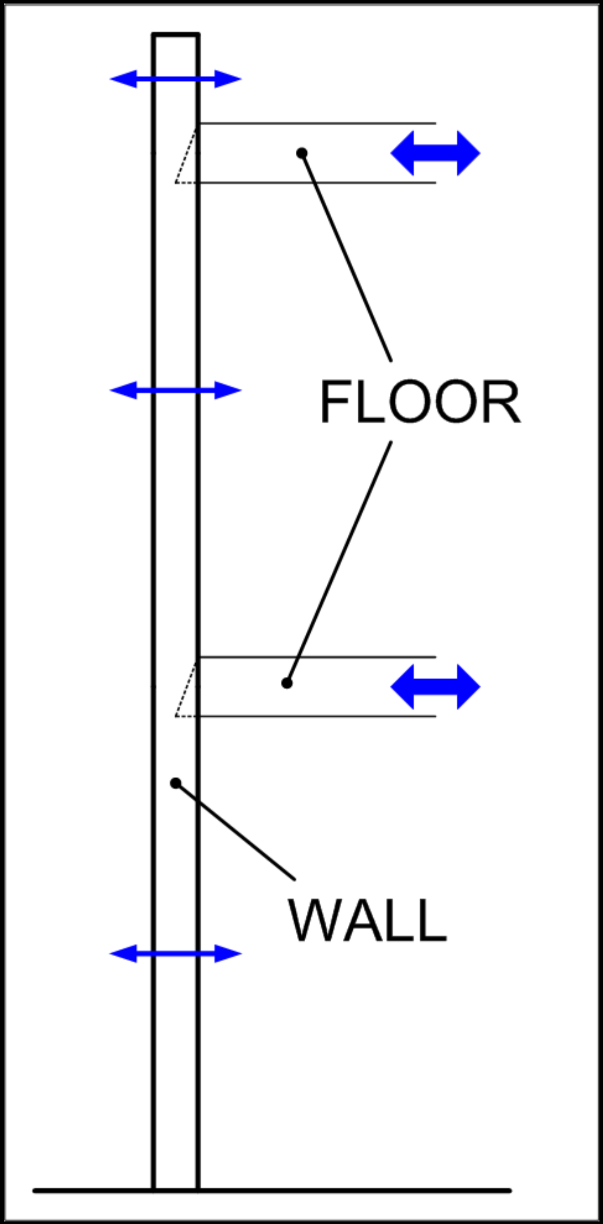
MASONRY CONSTRUCTION

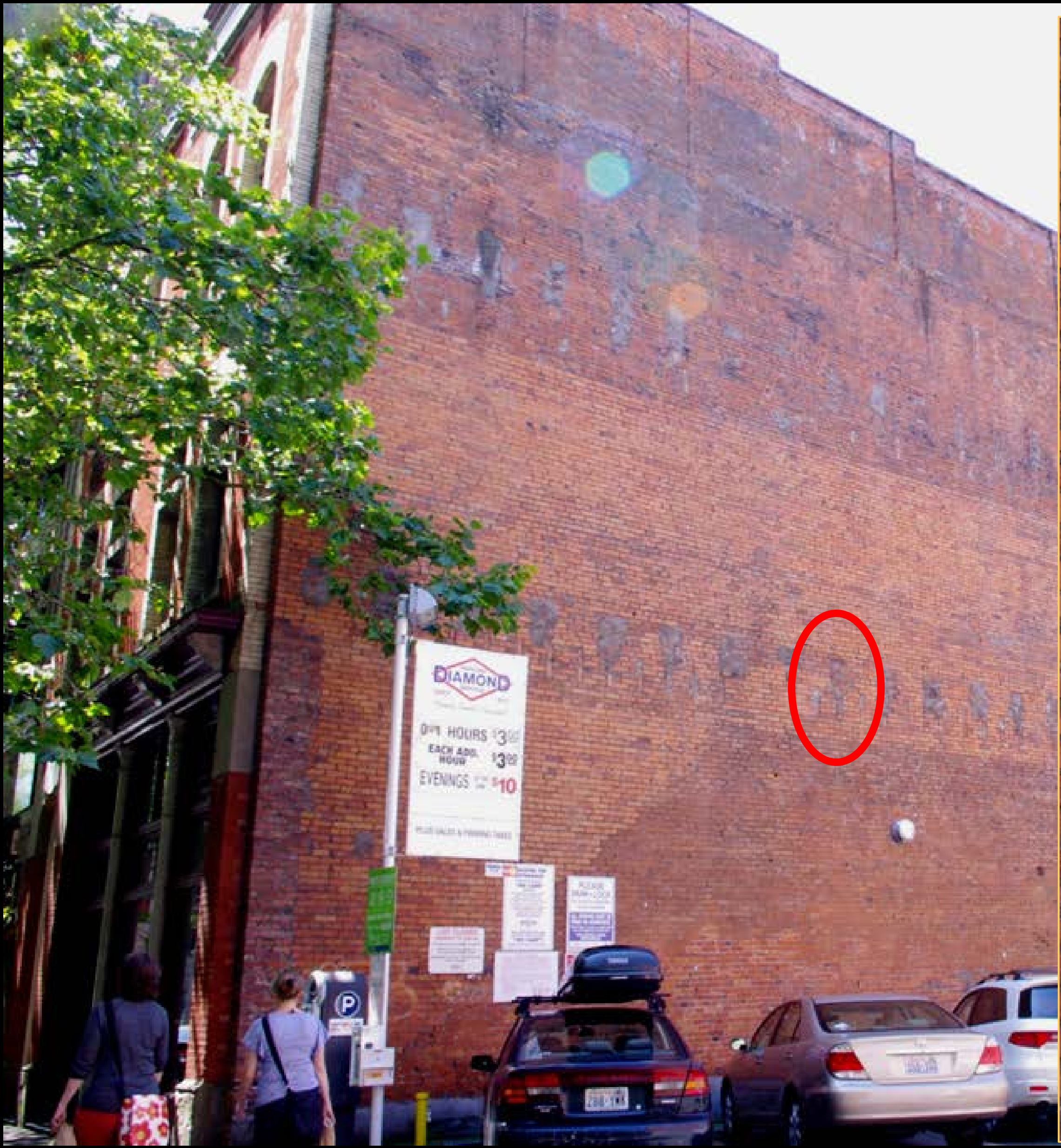
- Unreinforced brick masonry bearing wall buildings (URM's)
- Unreinforced concrete block masonry bearing wall buildings

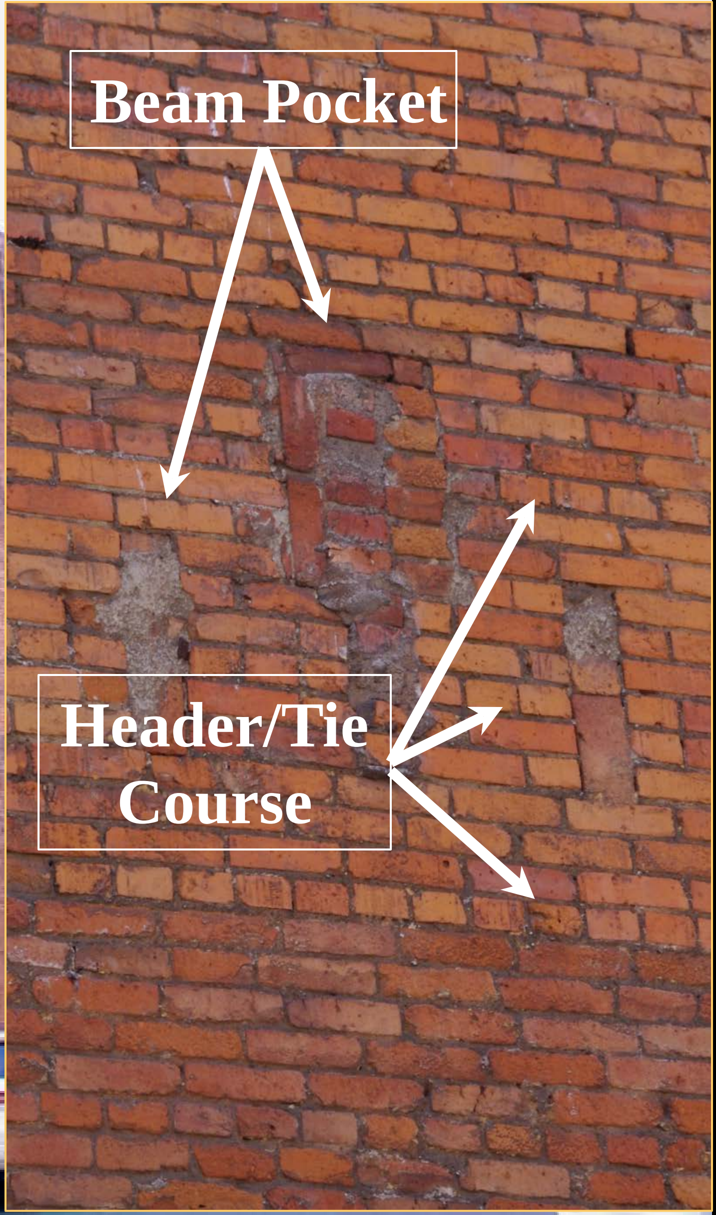
WHAT IS A URM?




Header/Tie Course


FLOOR
WALL

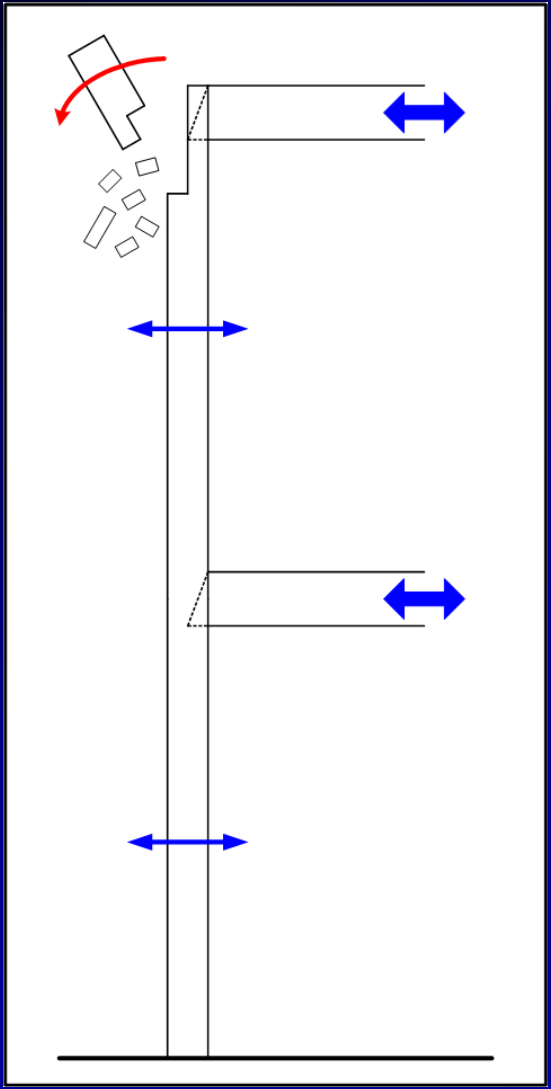


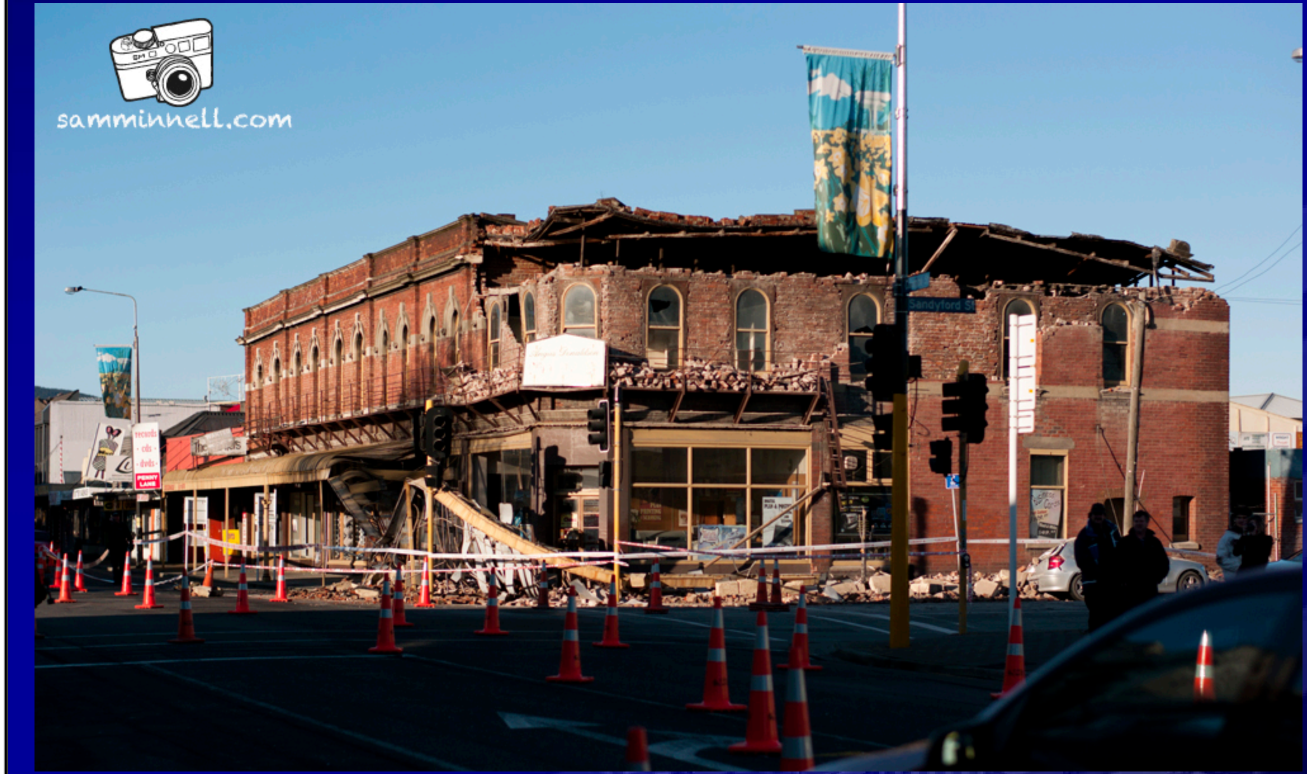


Beam Pocket

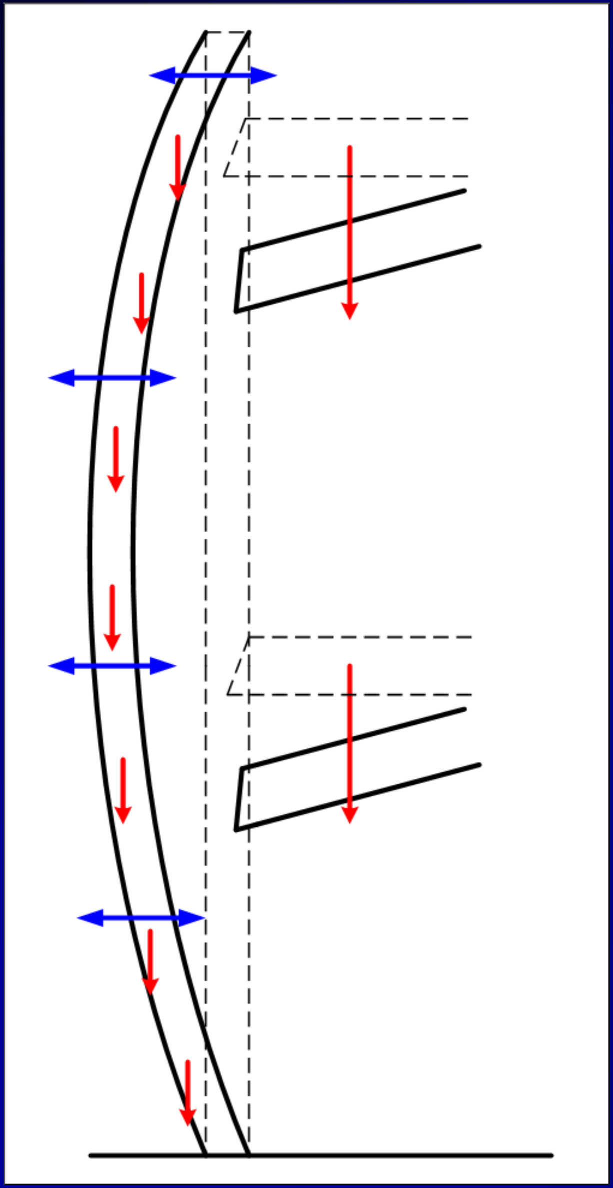
Header/Tie Course

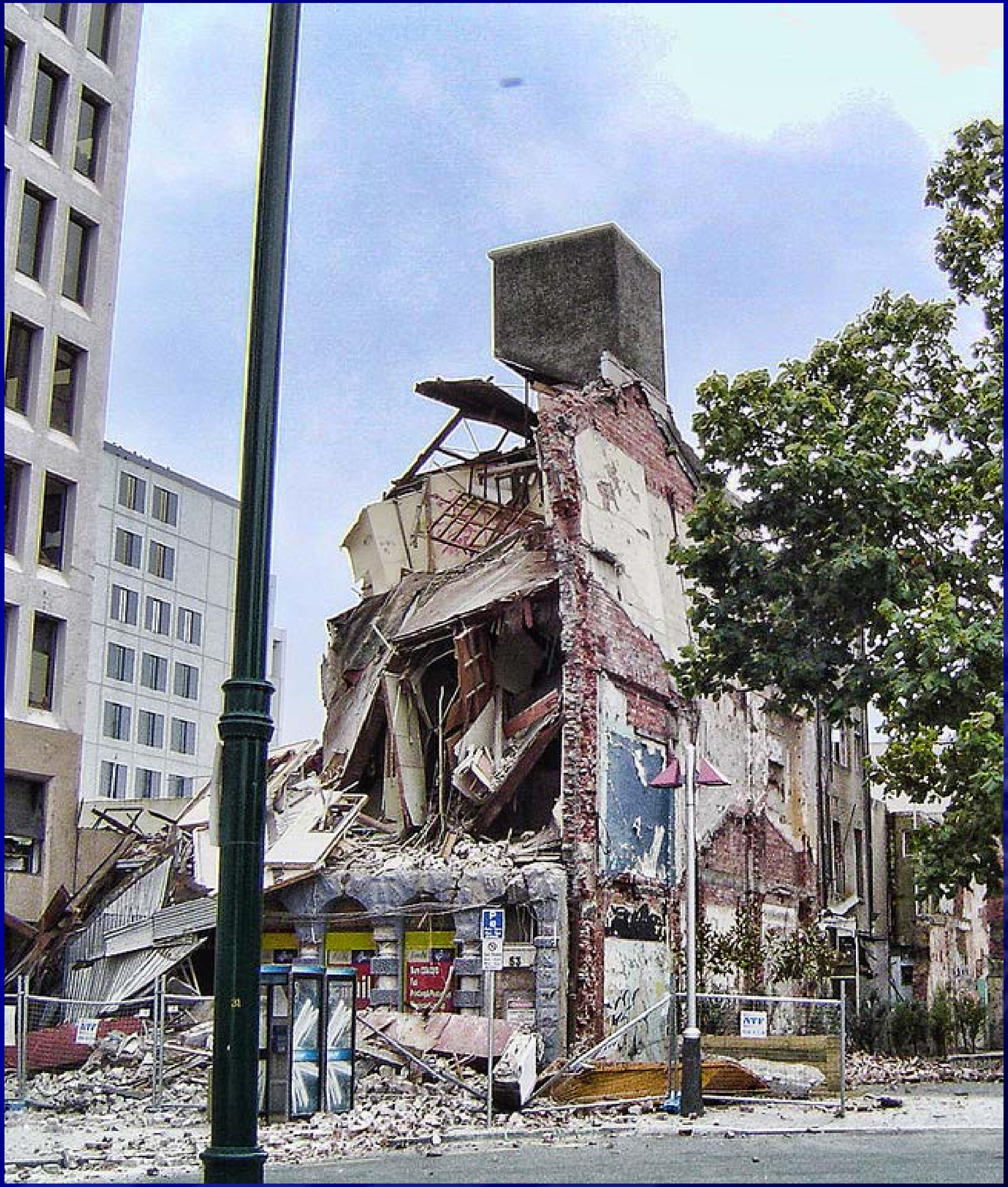
Earthquake (Mis)Behavior – URM's





Earthquake (Mis)Behavior – URM's





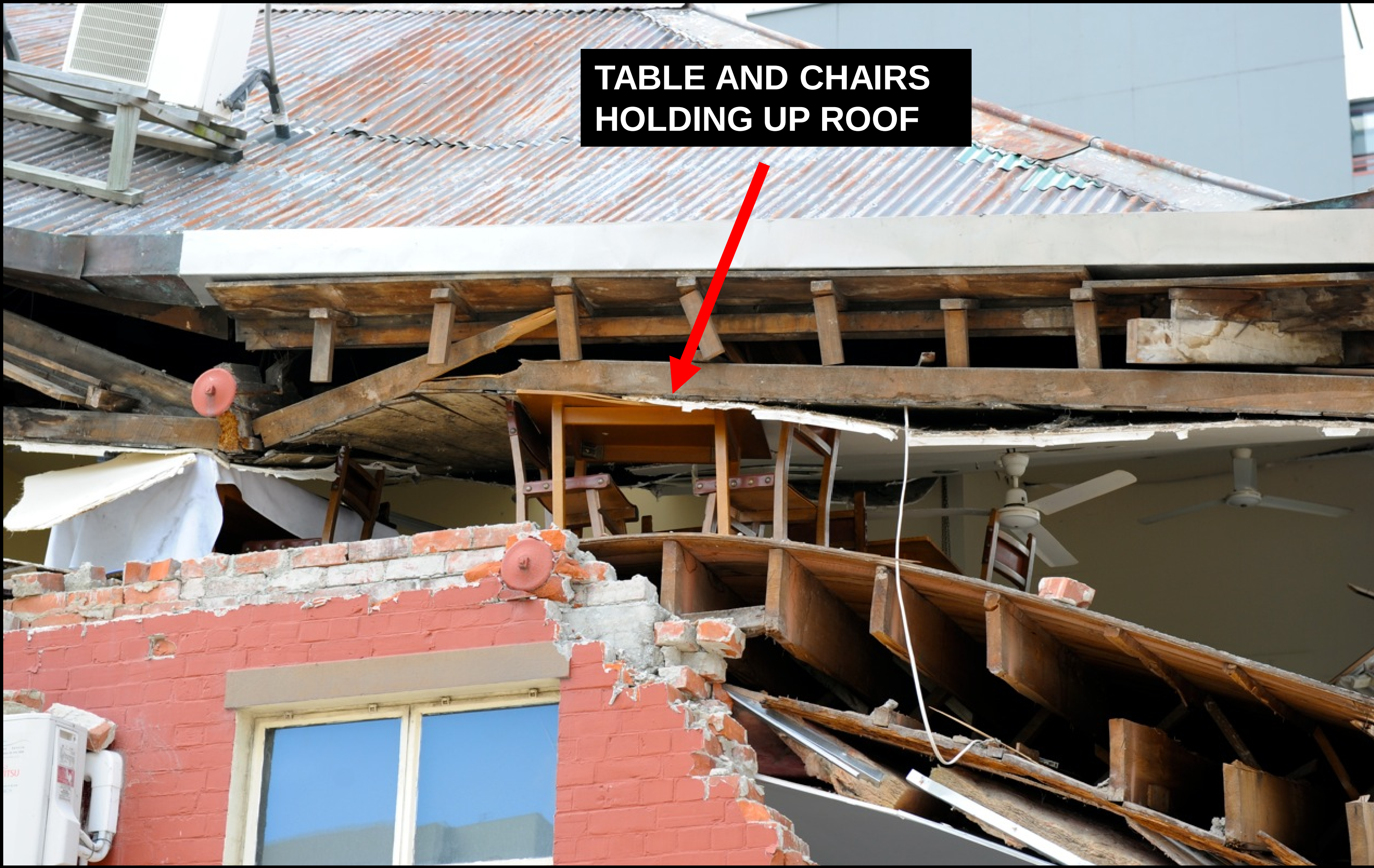
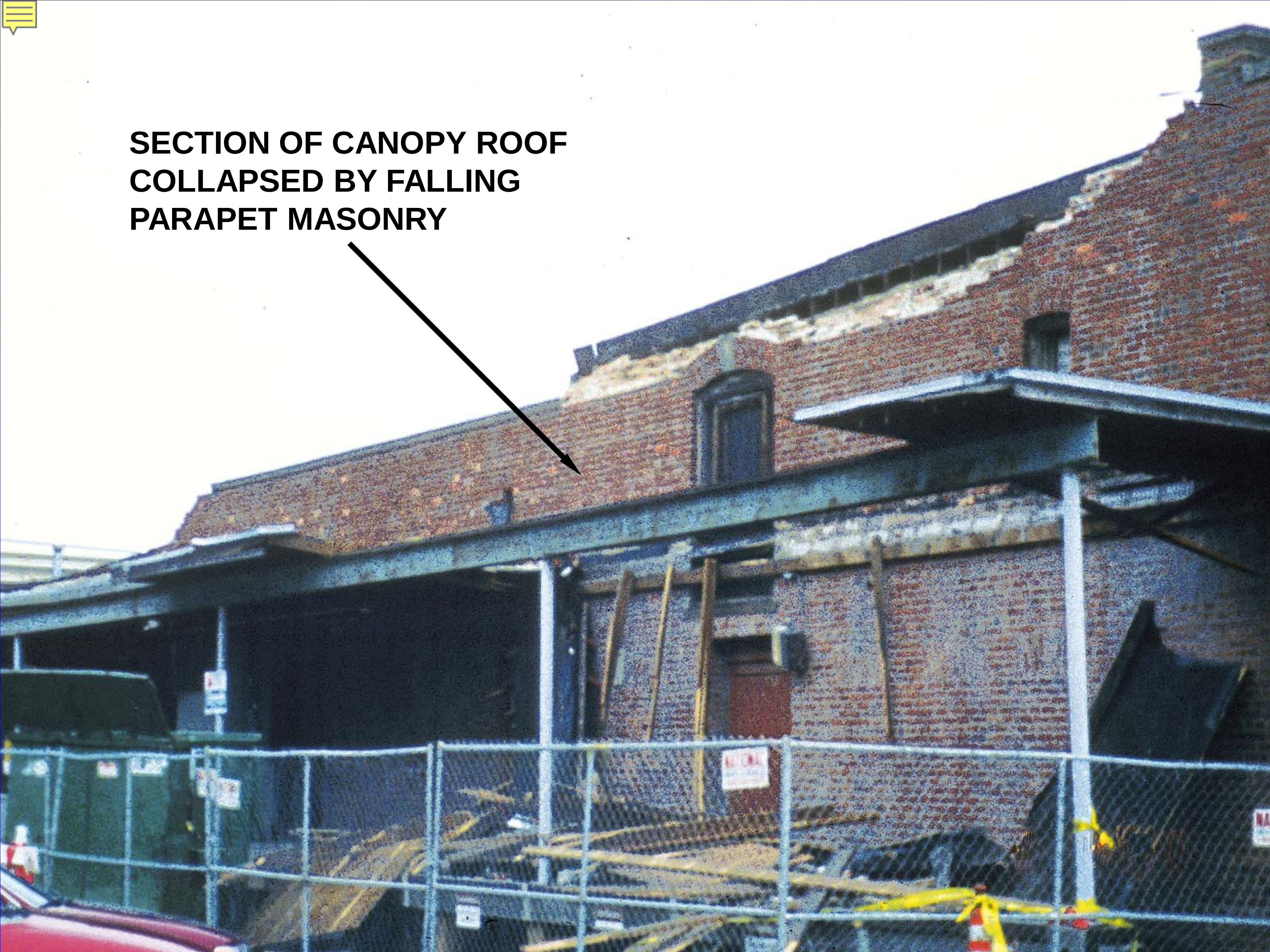
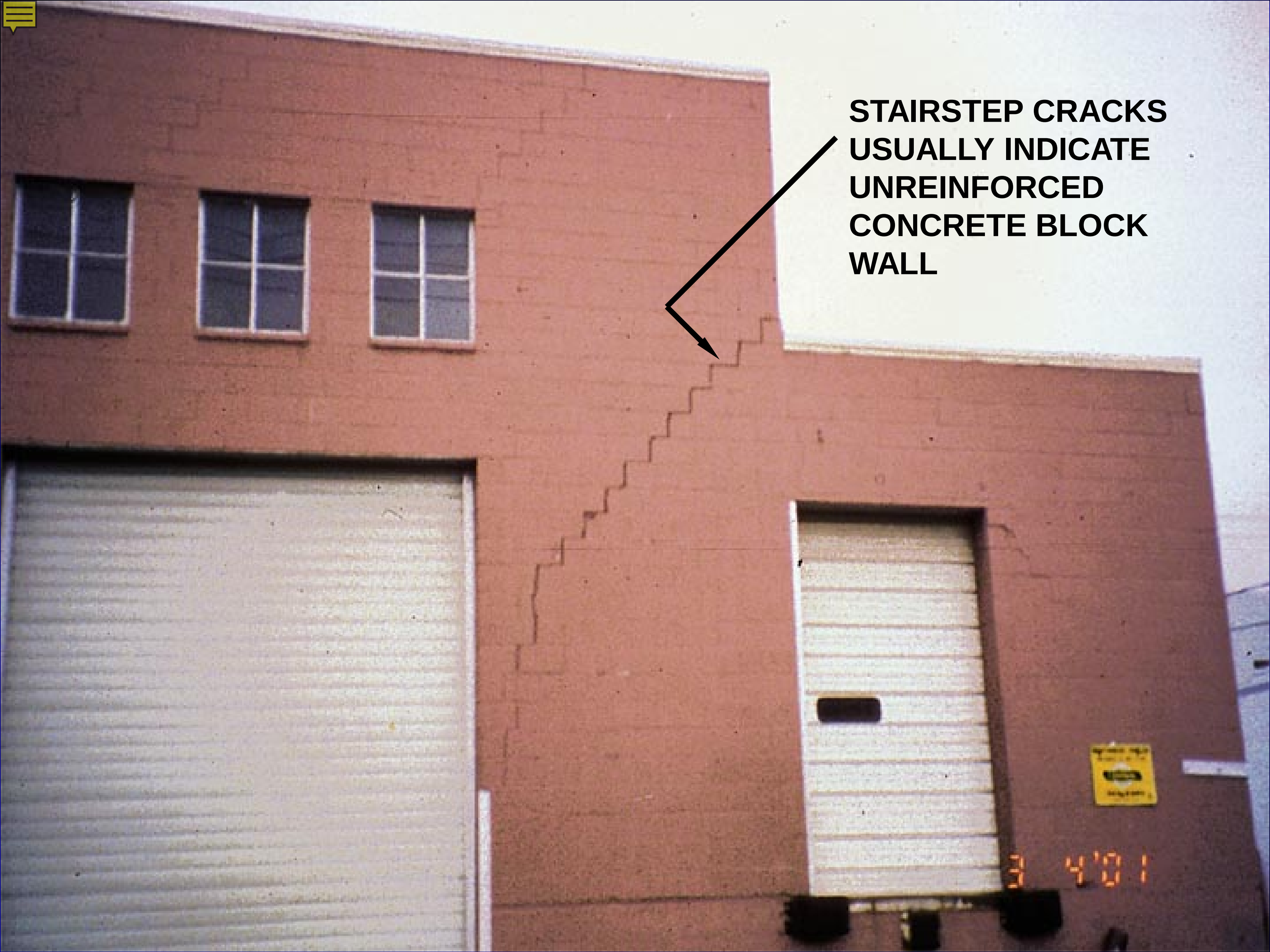


TABLE AND CHAIRS HOLDING UP ROOF



SECTION OF CANOPY ROOF COLLAPSED BY FALLING PARAPET MASONRY

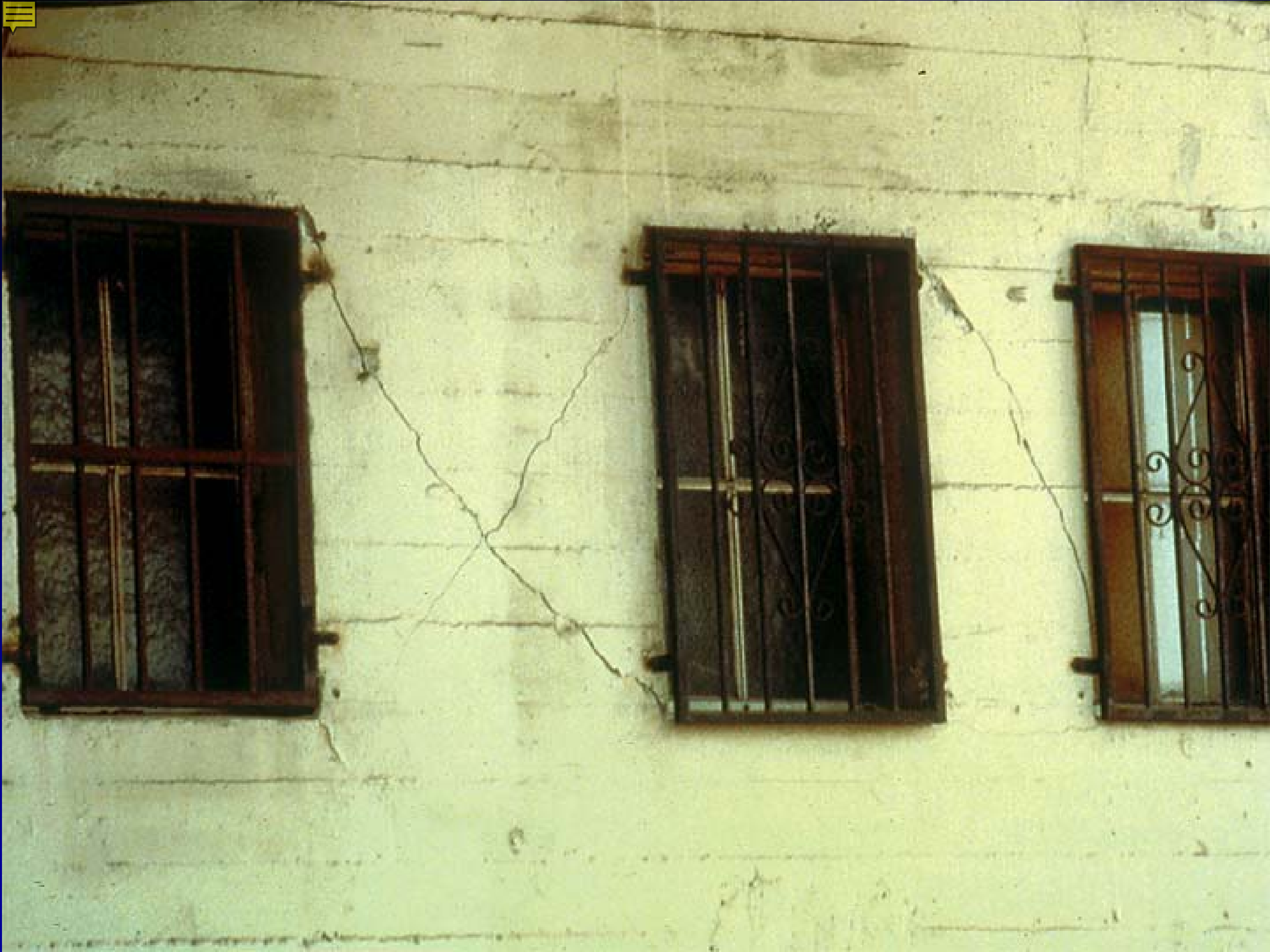


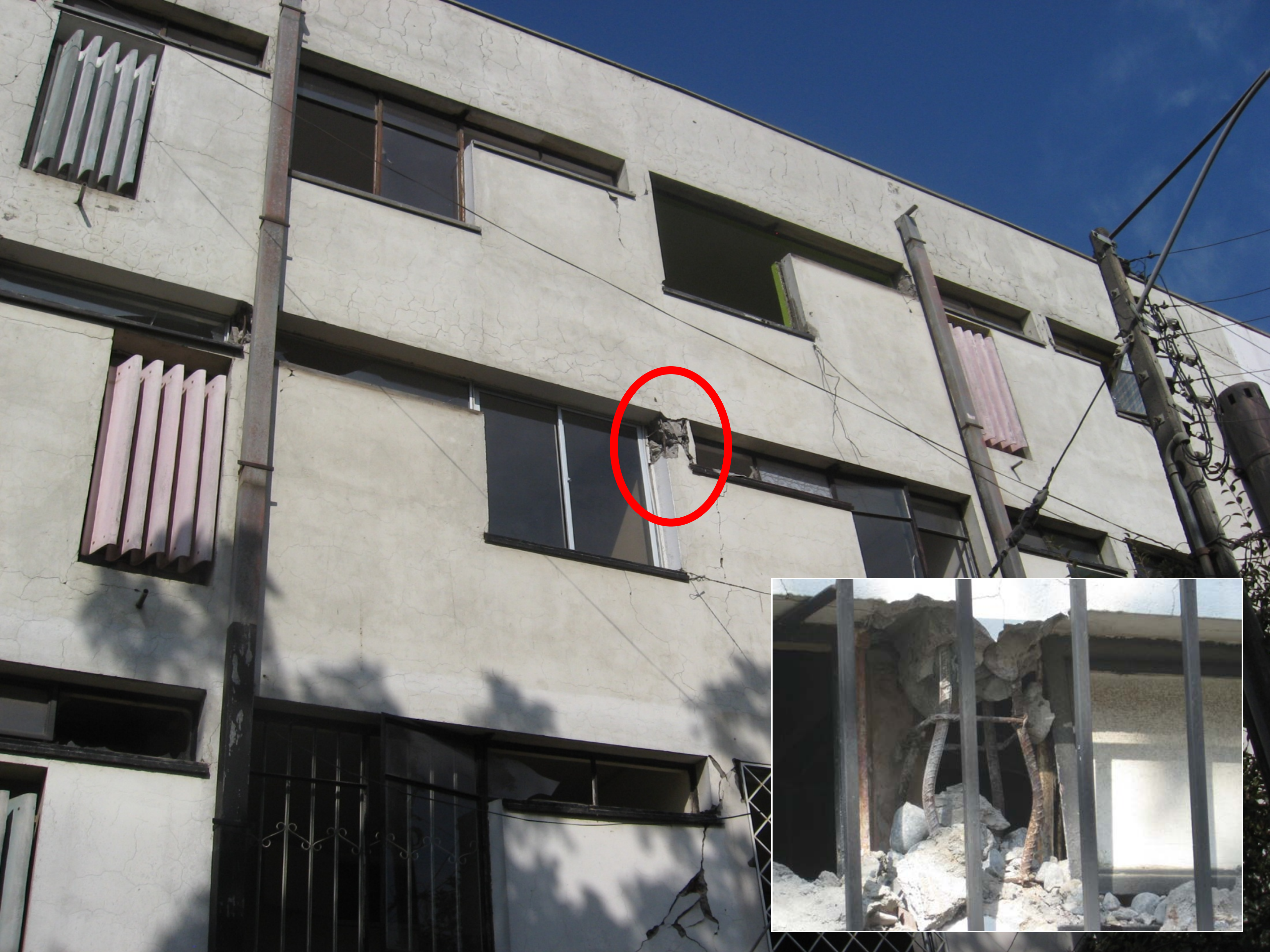
STAIRSTEP CRACKS USUALLY INDICATE UNREINFORCED CONCRETE BLOCK WALL

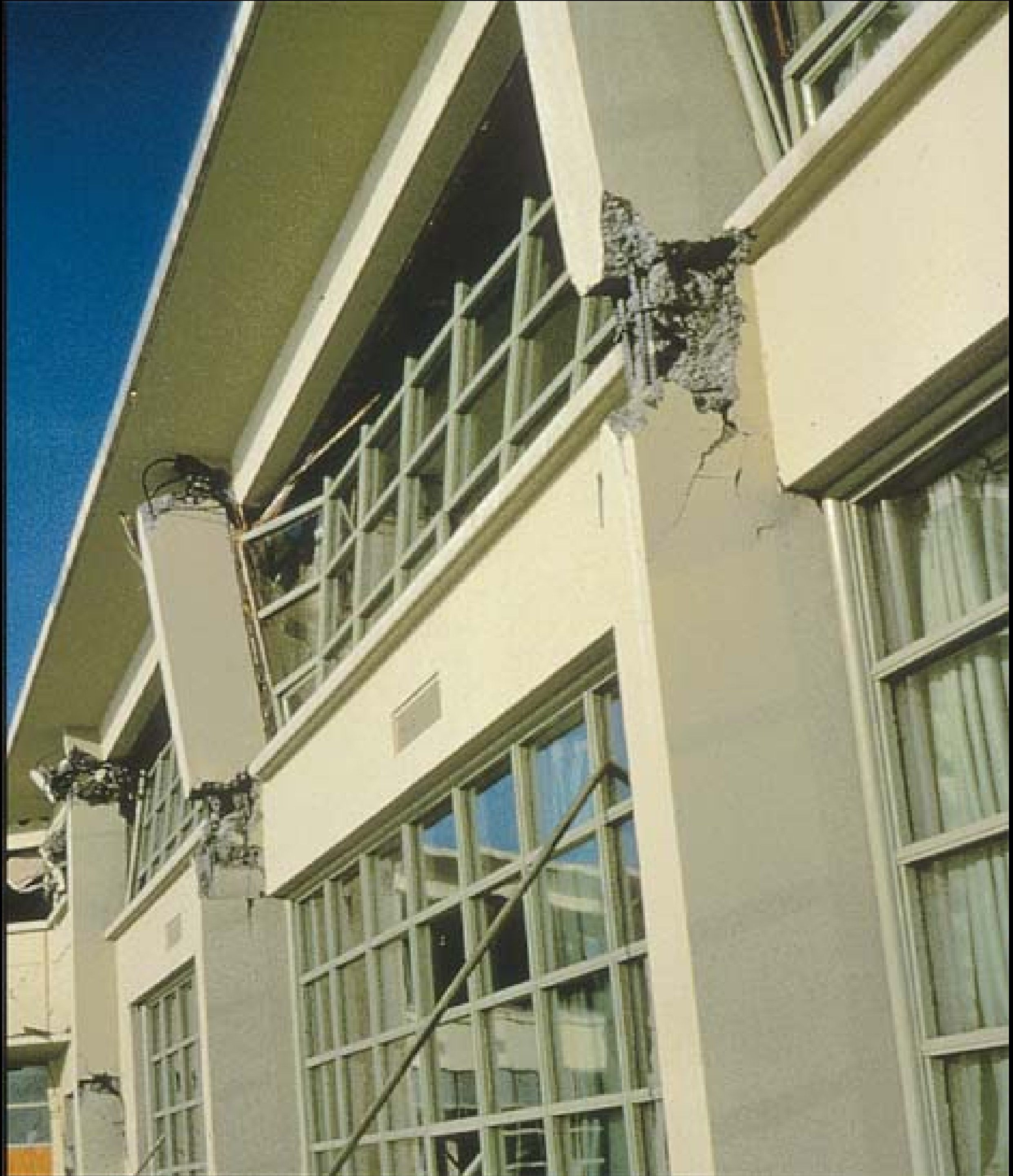
3 4'01

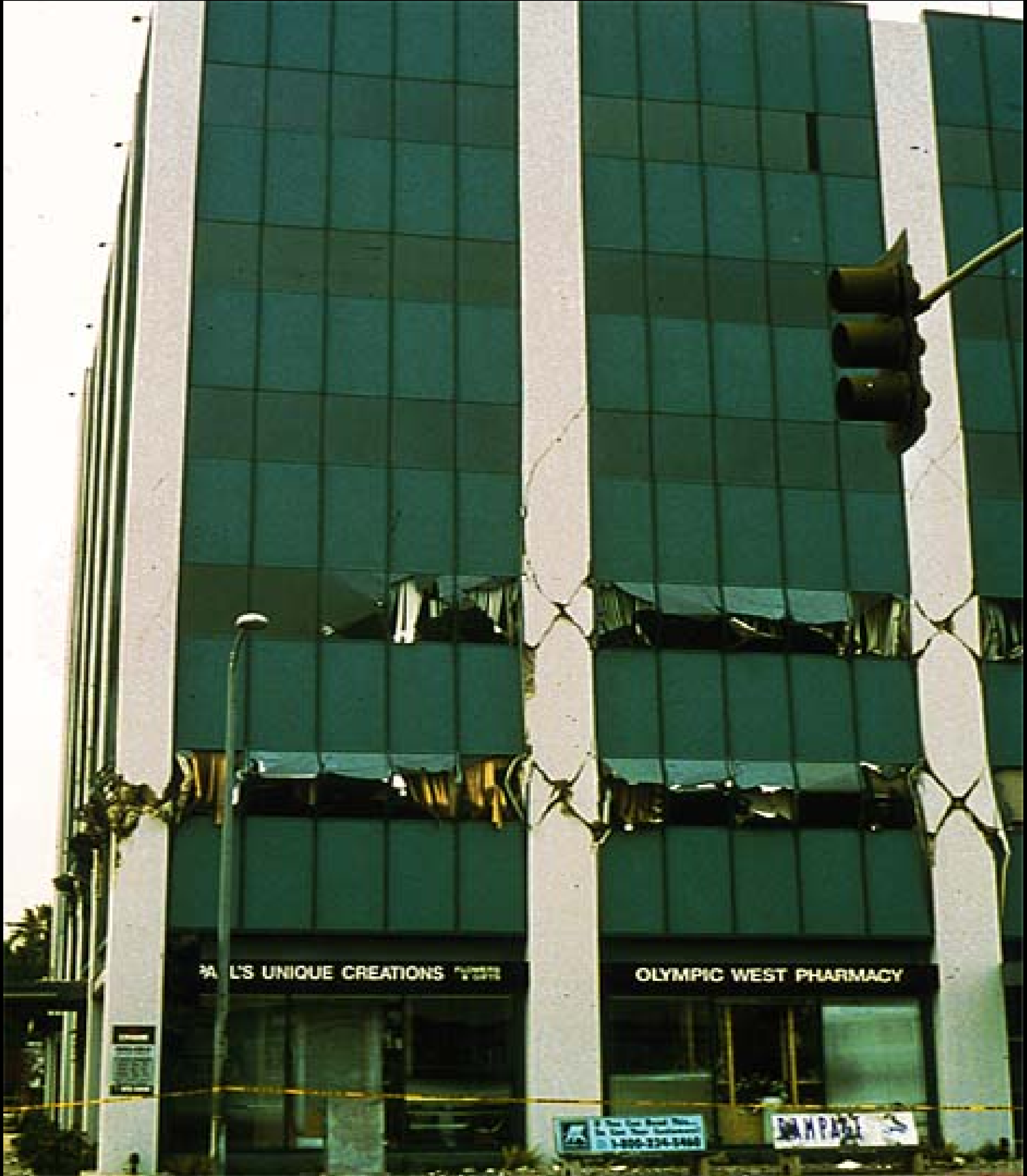
CONCRETE CONSTRUCTION

- Structural walls or frames
- Cast-in-place or precast
- Combinations of the above



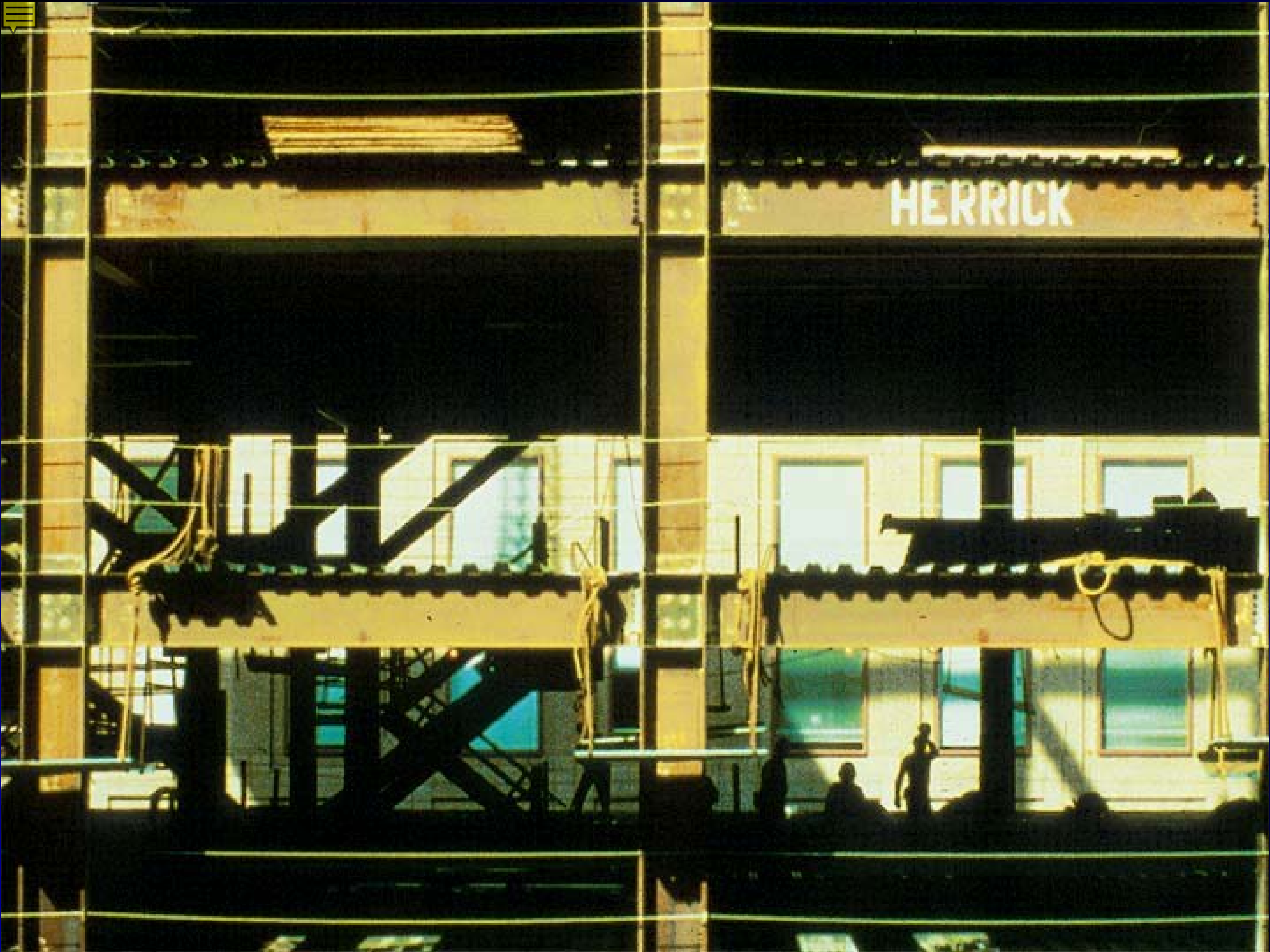


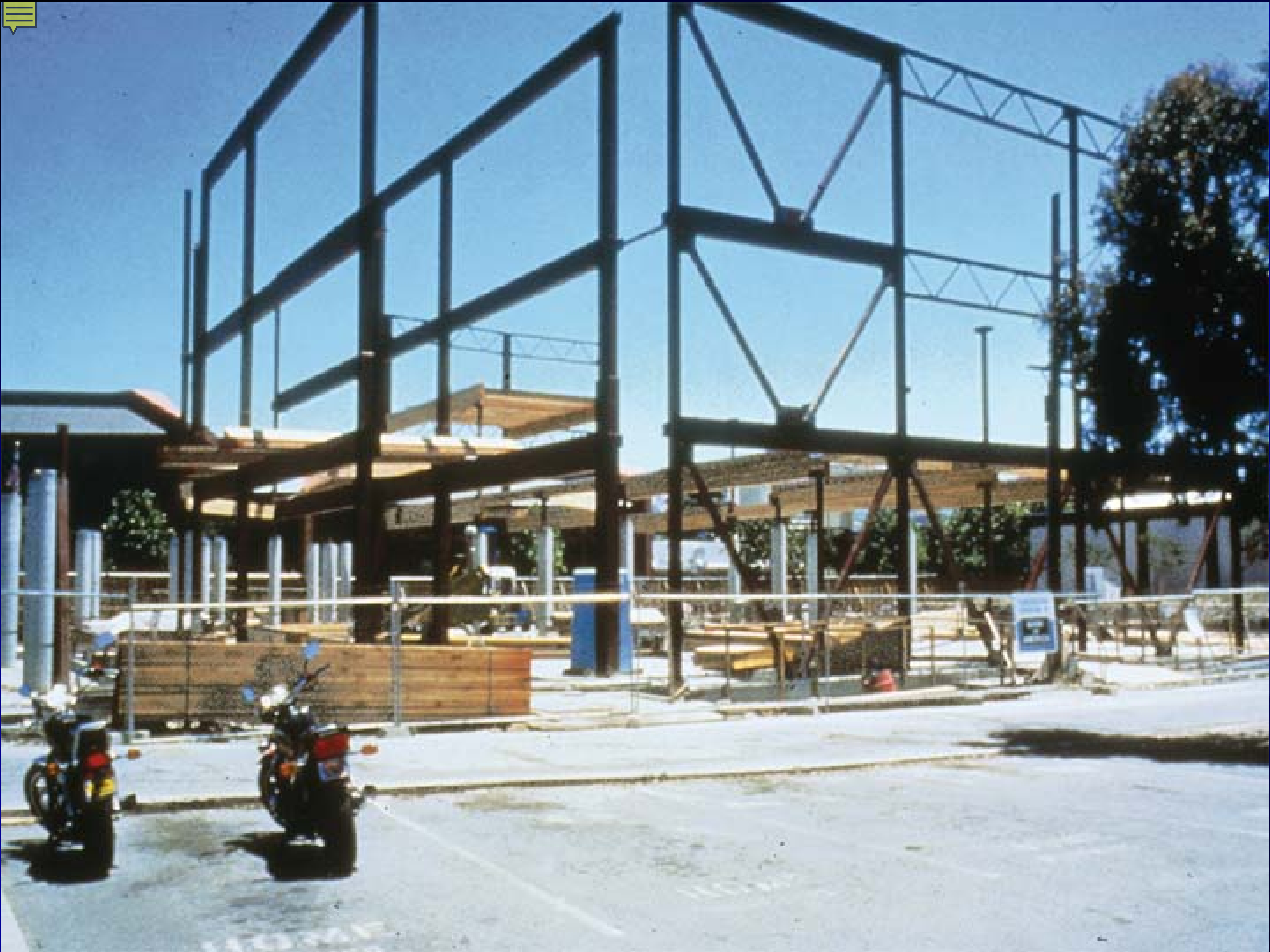



PA L'S UNIQUE CREATIONS
OLYMPIC WEST PHARMACY

STEEL-FRAME CONSTRUCTION

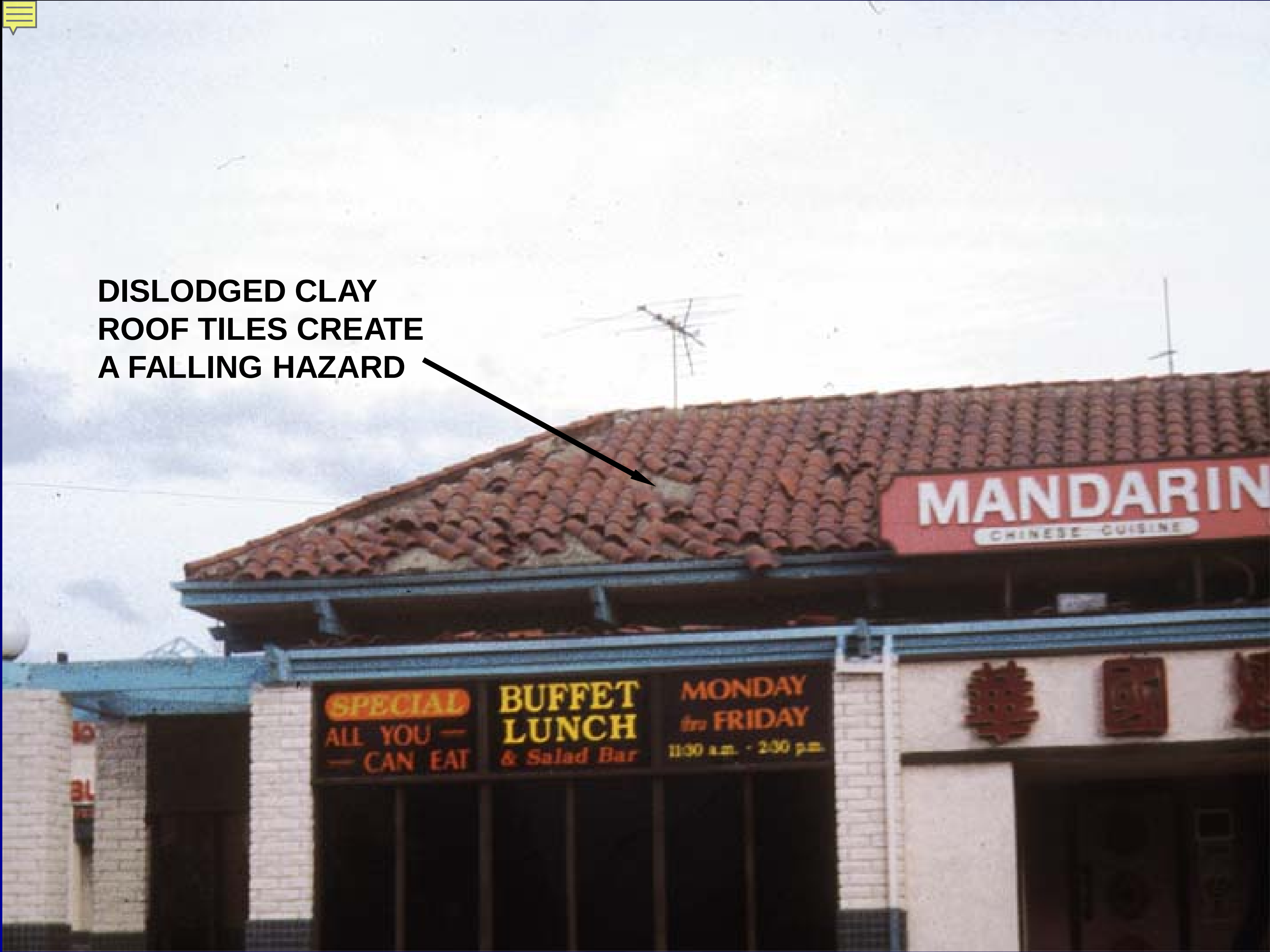
- Multi-story fire resistive frame
- Pre-engineered light frame


HERRICK

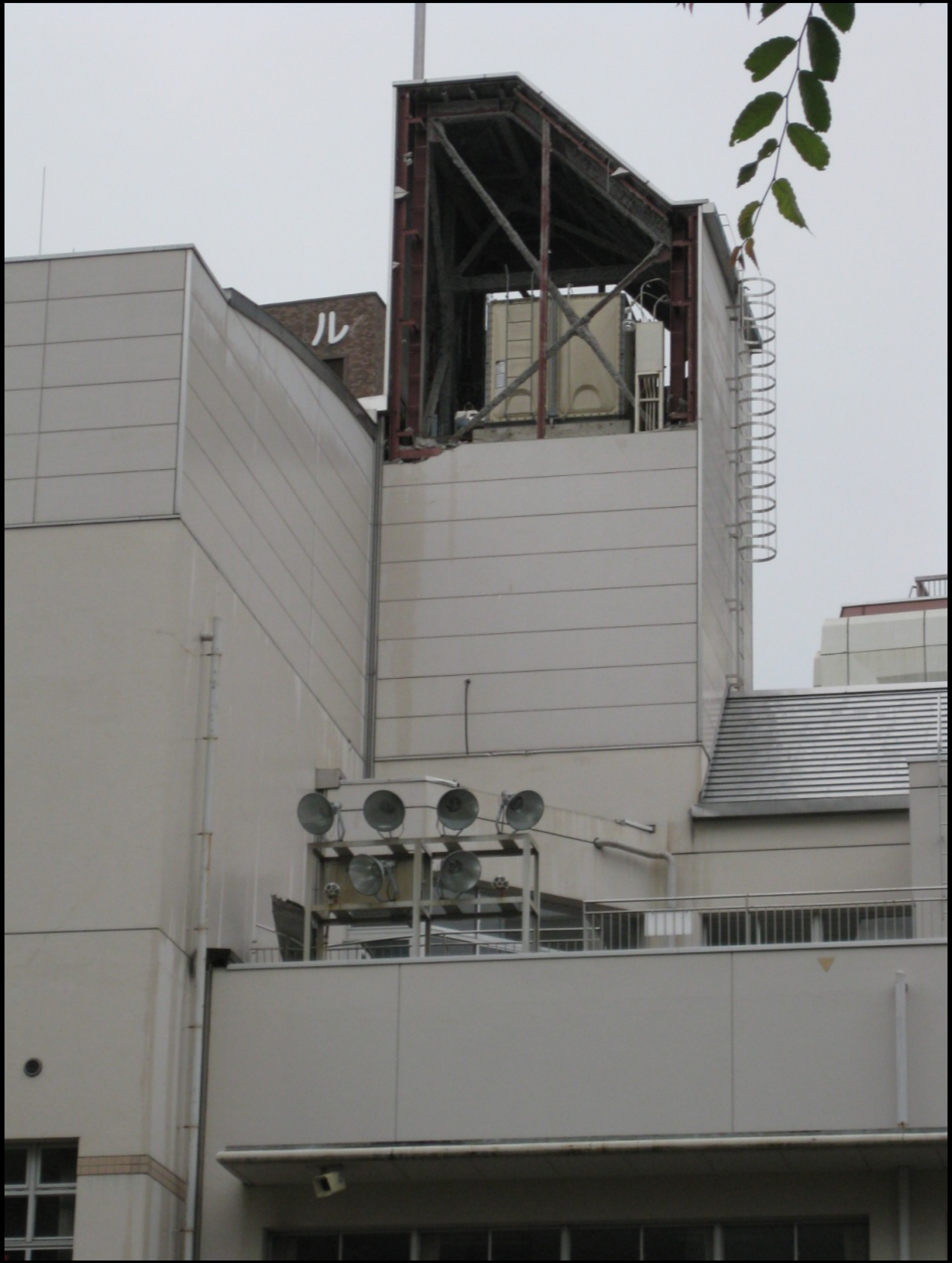


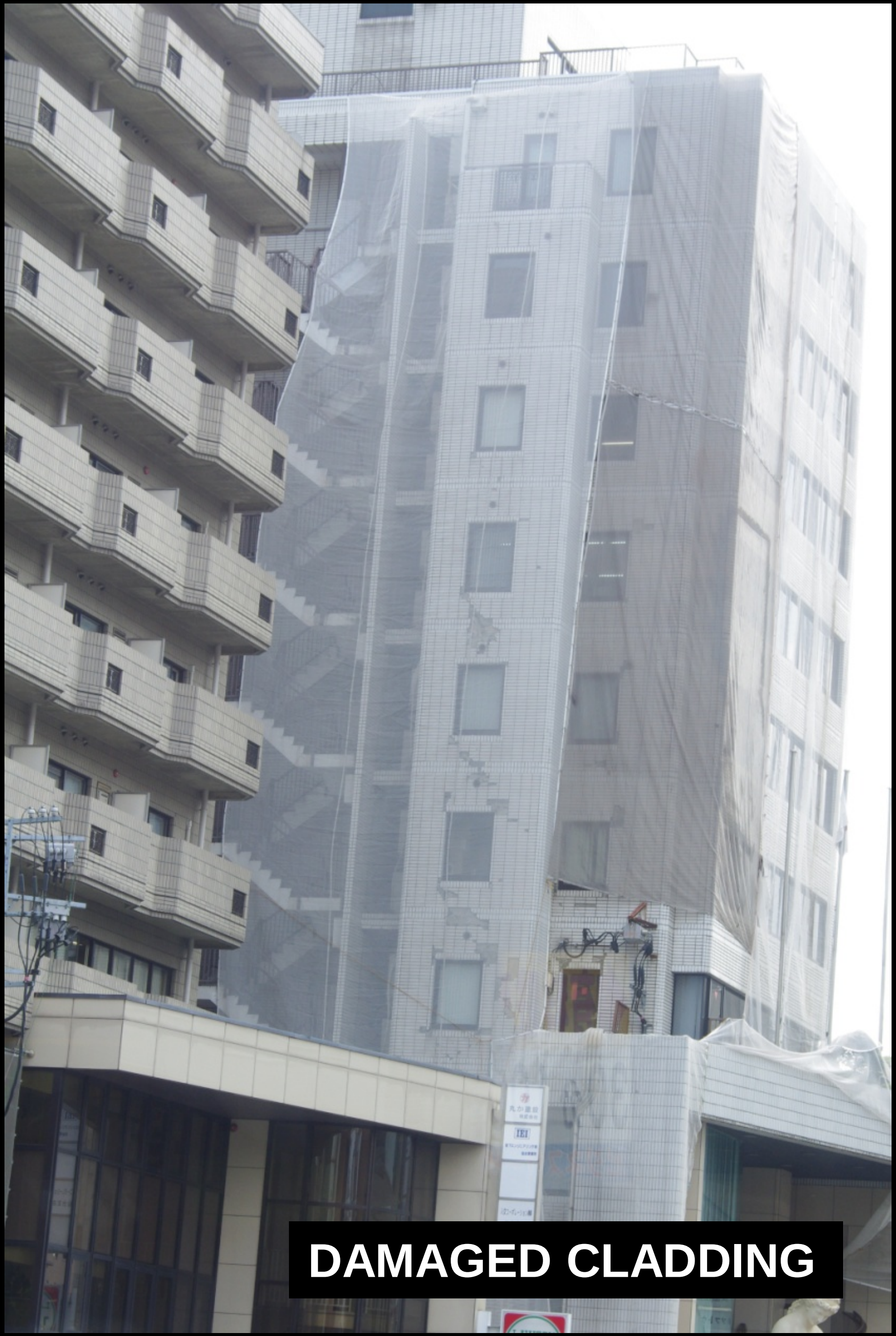
NONSTRUCTURAL ELEMENTS

- Parapets, chimneys, ornamentation
- Cladding and glazing
- Interior walls
- Suspended ceilings, raised floors
- Equipment, furnishings



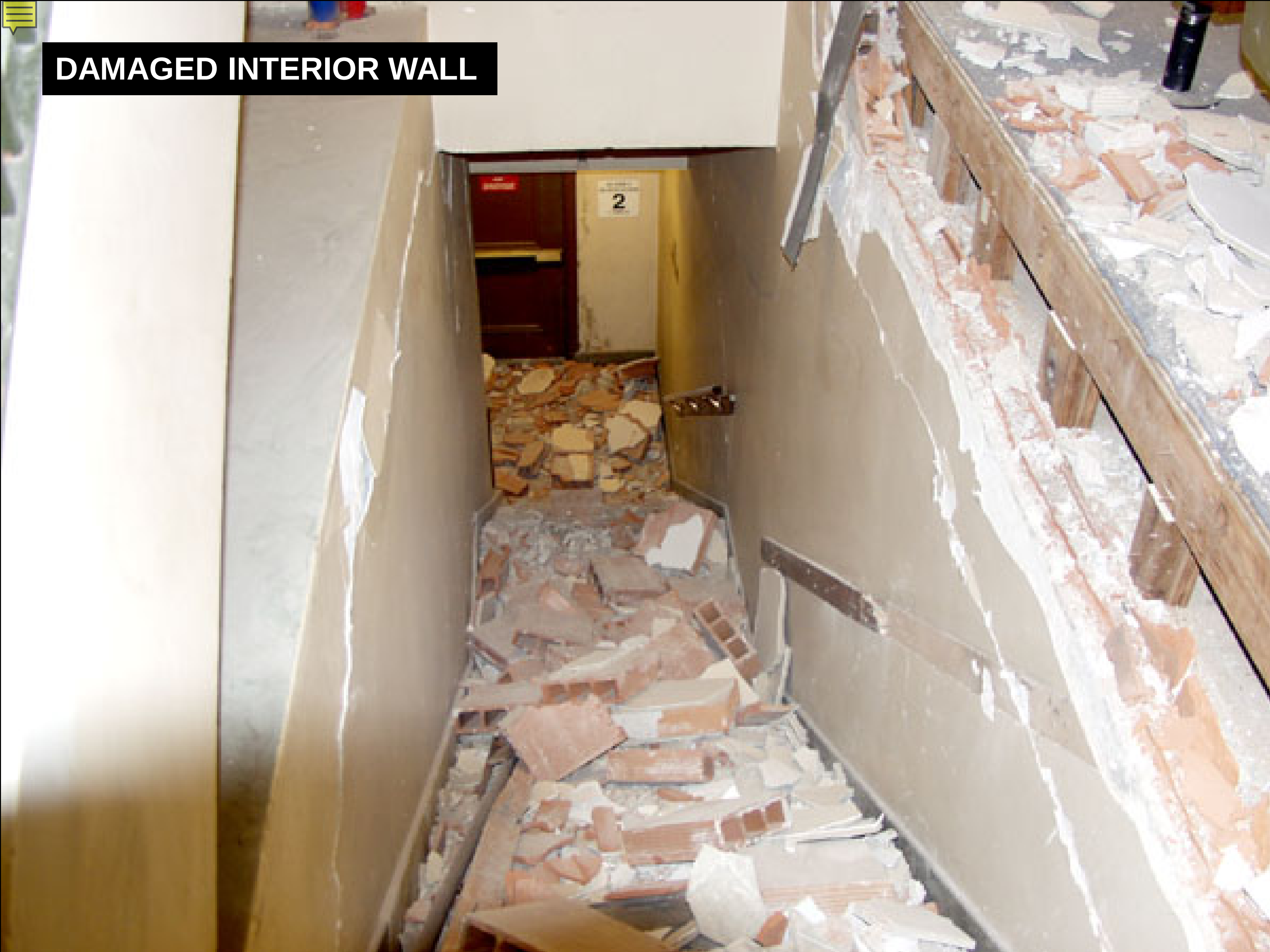
DISLODGED CLAY ROOF TILES CREATE A FALLING HAZARD



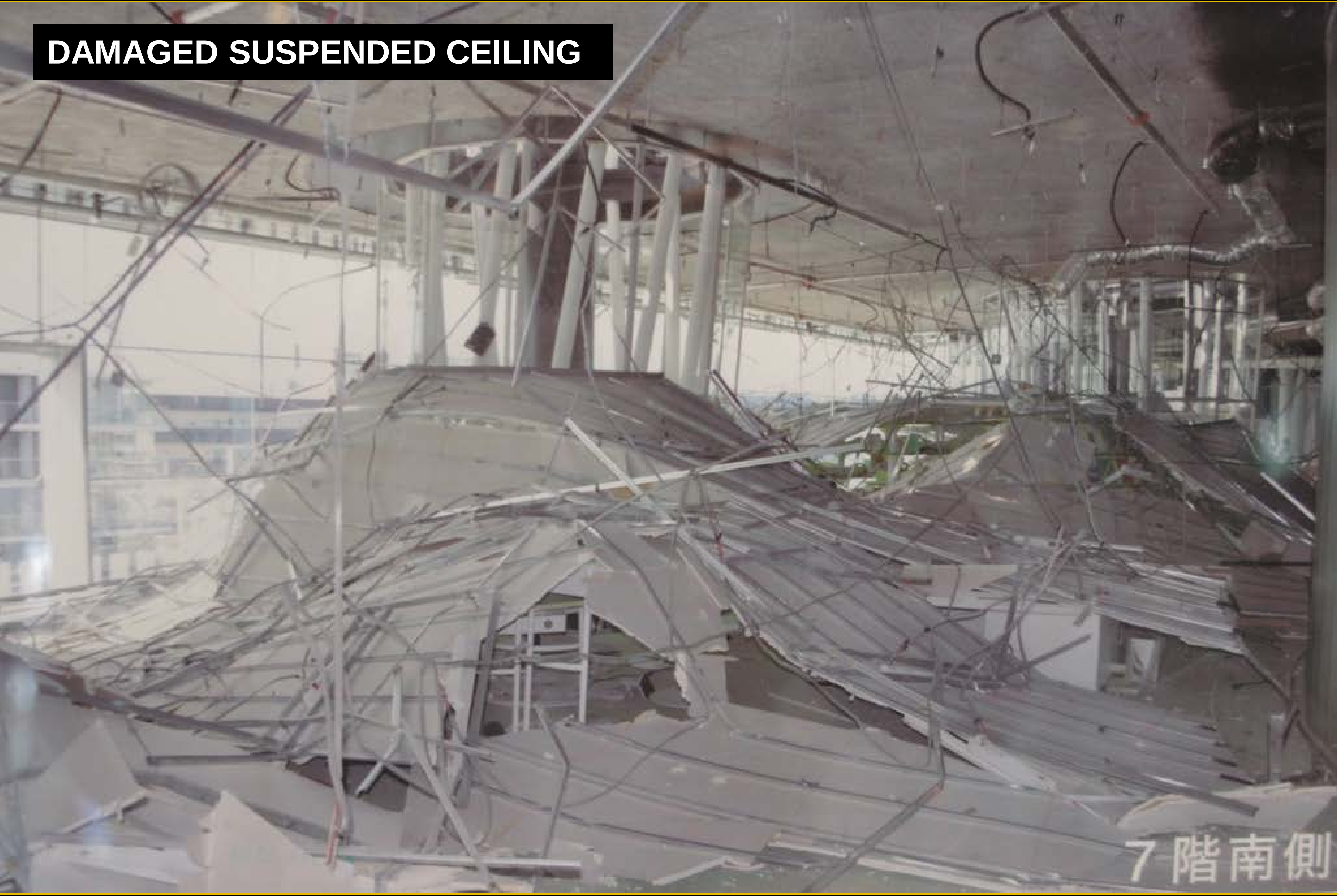


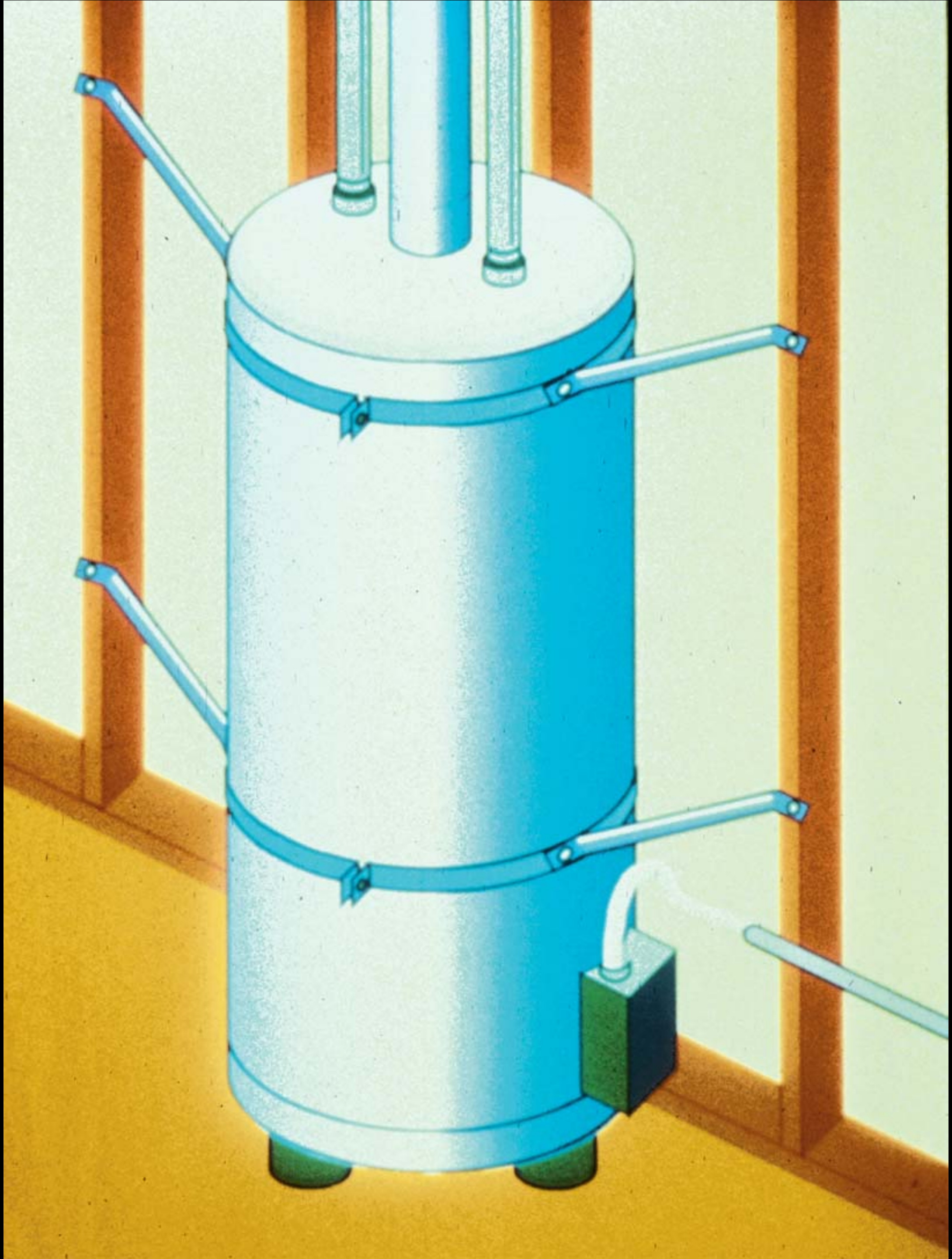
DAMAGED CLADDING

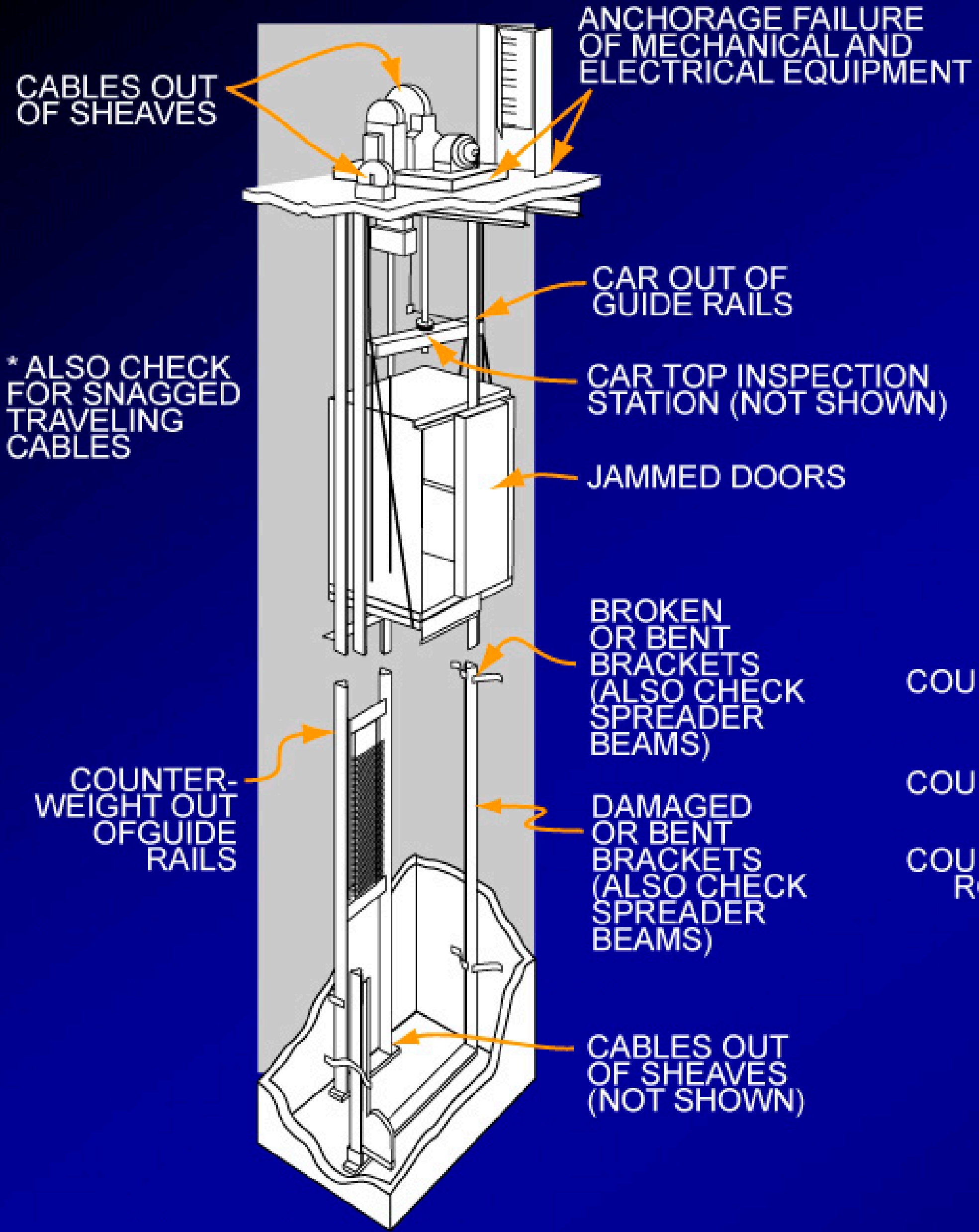
DAMAGED INTERIOR WALL

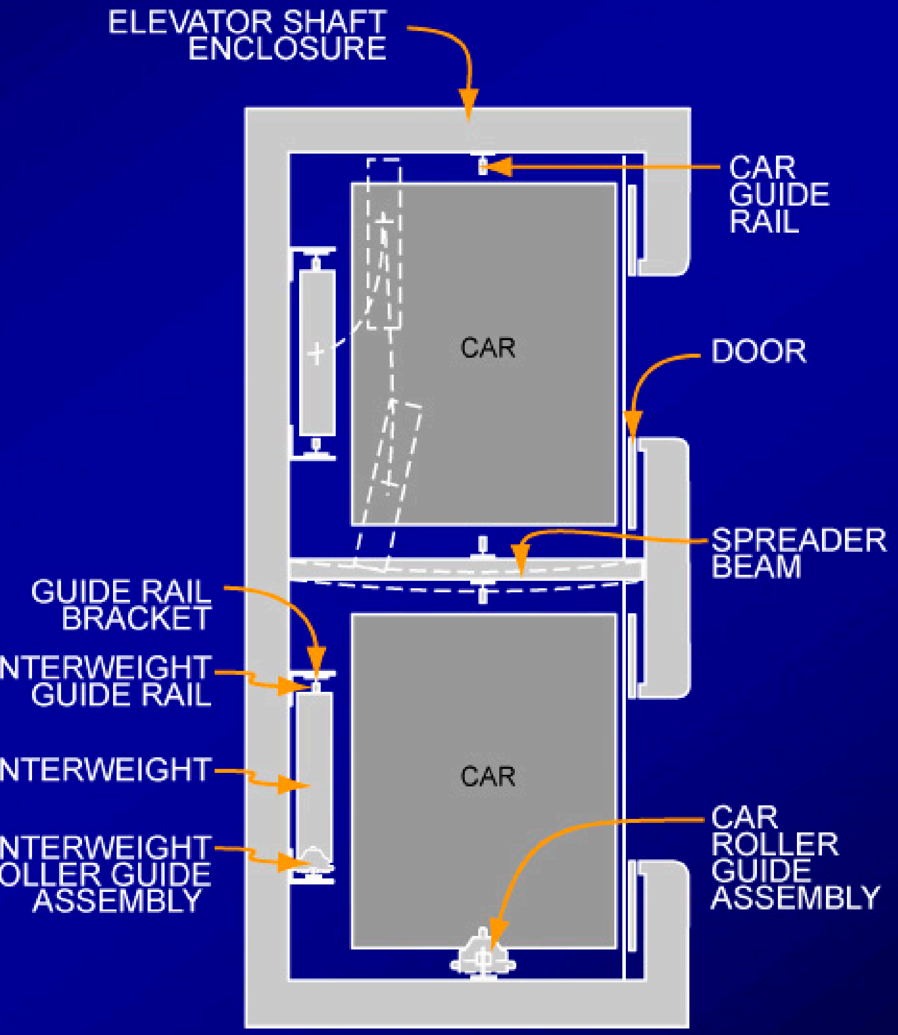


DAMAGED SUSPENDED CEILING

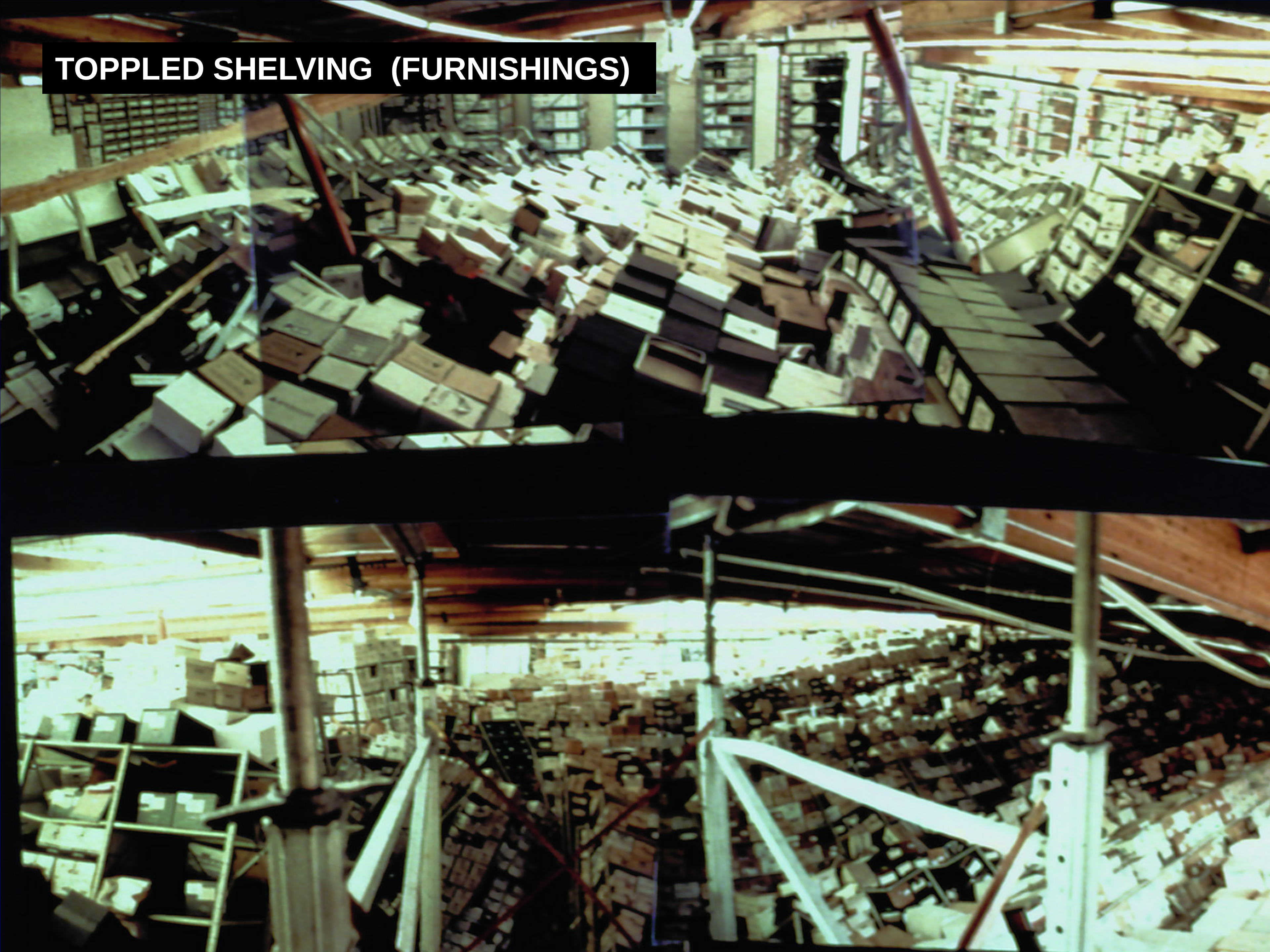





CABLES OUT OF SHEAVES
ANCHORAGE FAILURE OF MECHANICAL AND ELECTRICAL EQUIPMENT
CAR OUT OF GUIDE RAILS
* ALSO CHECK FOR SNAGGED TRAVELING CABLES
CAR TOP INSPECTION STATION (NOT SHOWN)
JAMMED DOORS
BROKEN OR BENT BRACKETS (ALSO CHECK SPREADER BEAMS)
COUNTER-WEIGHT OUT OFGUIDE RAILS
DAMAGED OR BENT BRACKETS (ALSO CHECK SPREADER BEAMS)
CABLES OUT OF SHEAVES (NOT SHOWN)


ELEVATOR SHAFT ENCLOSURE
CAR GUIDE RAIL
CAR
DOOR
SPREADER BEAM
GUIDE RAIL BRACKET
COUNTERWEIGHT GUIDE RAIL
COUNTERWEIGHT
CAR
COUNTERWEIGHT ROLLER GUIDE ASSEMBLY
CAR ROLLER GUIDE ASSEMBLY

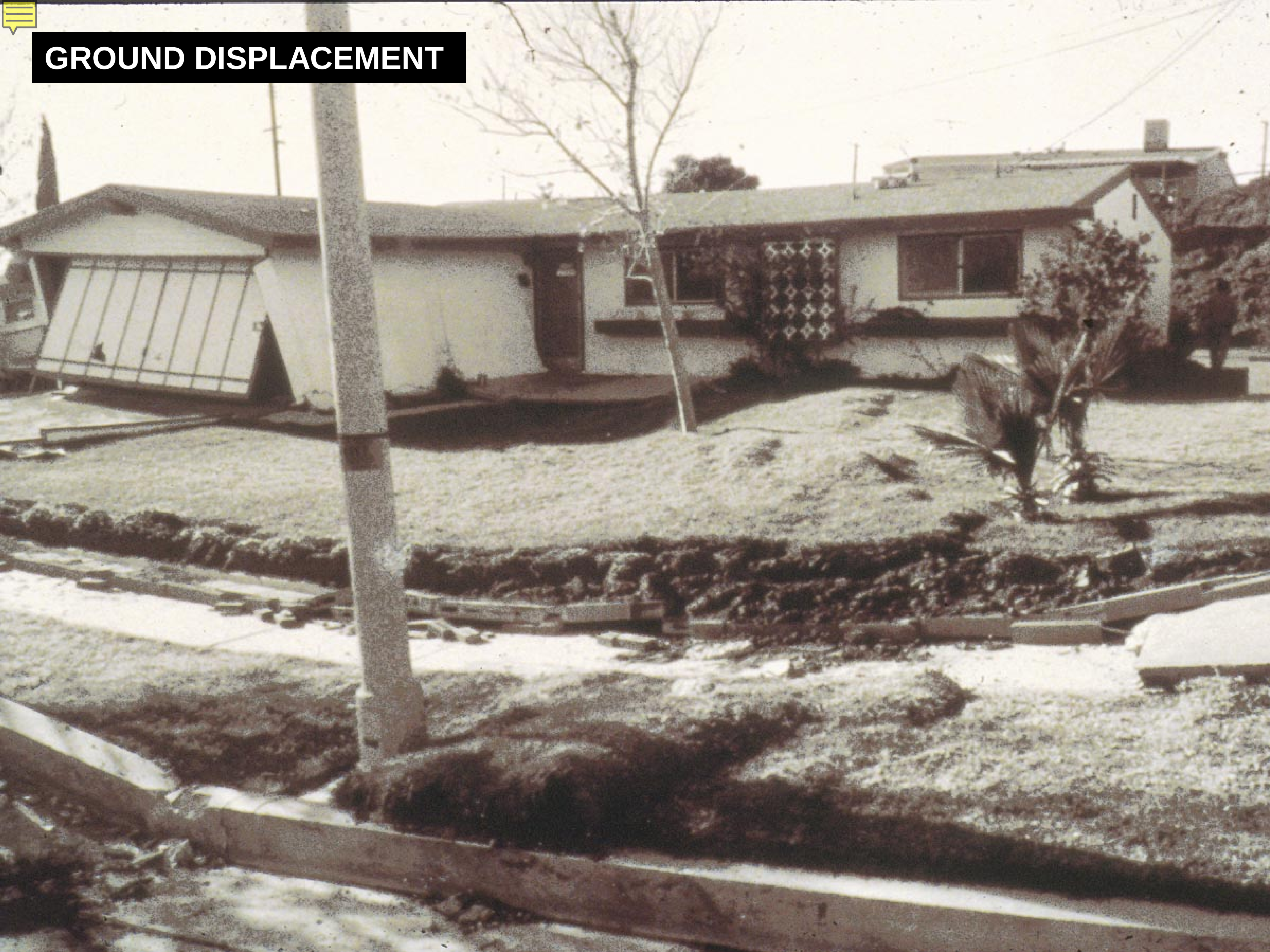
TOPPLED SHELVING (FURNISHINGS)

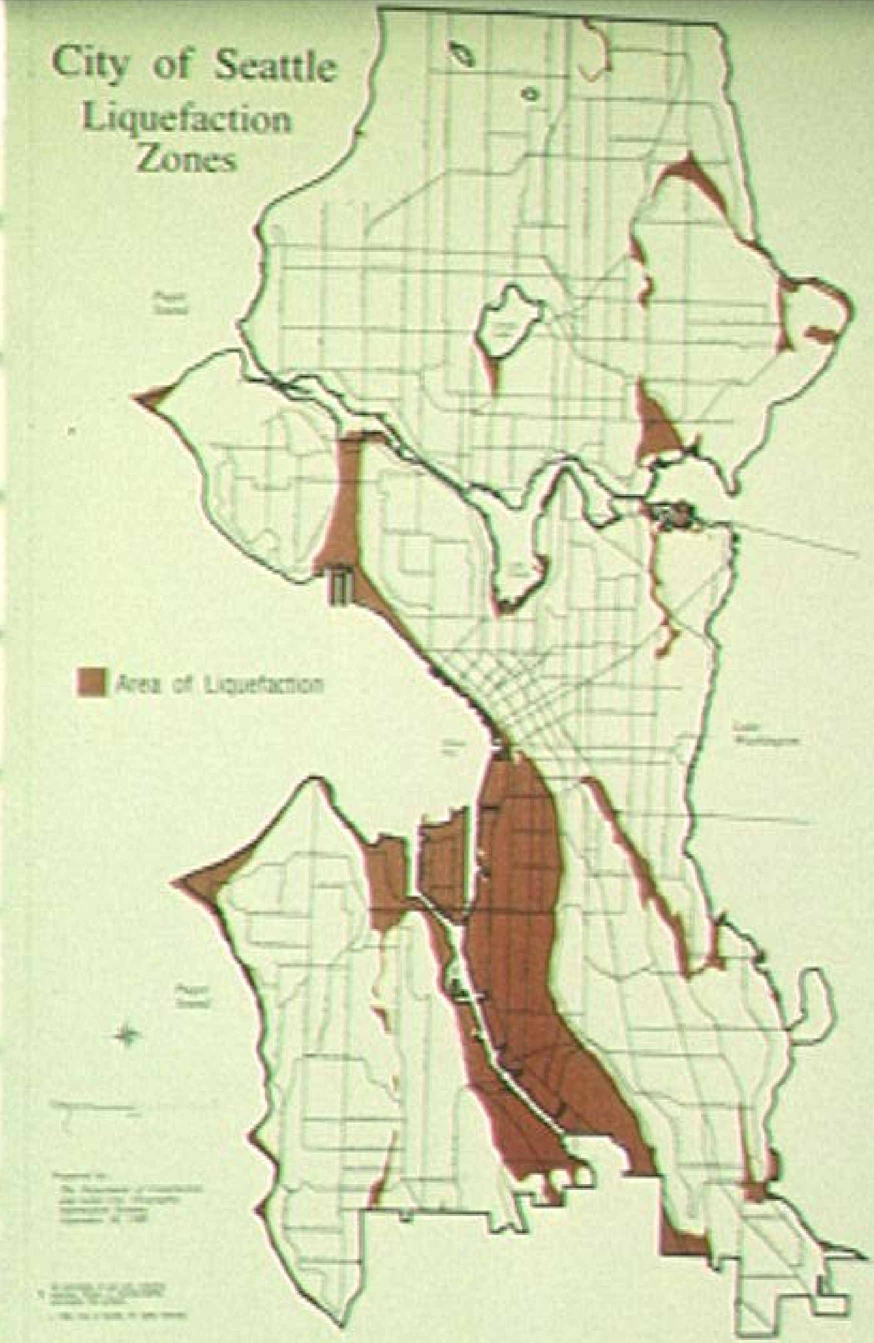


GEOTECHNICAL HAZARDS

- Ground displacement
- Increased shaking
- Liquefaction/Lateral spreading
- Subsidence
- Landslides

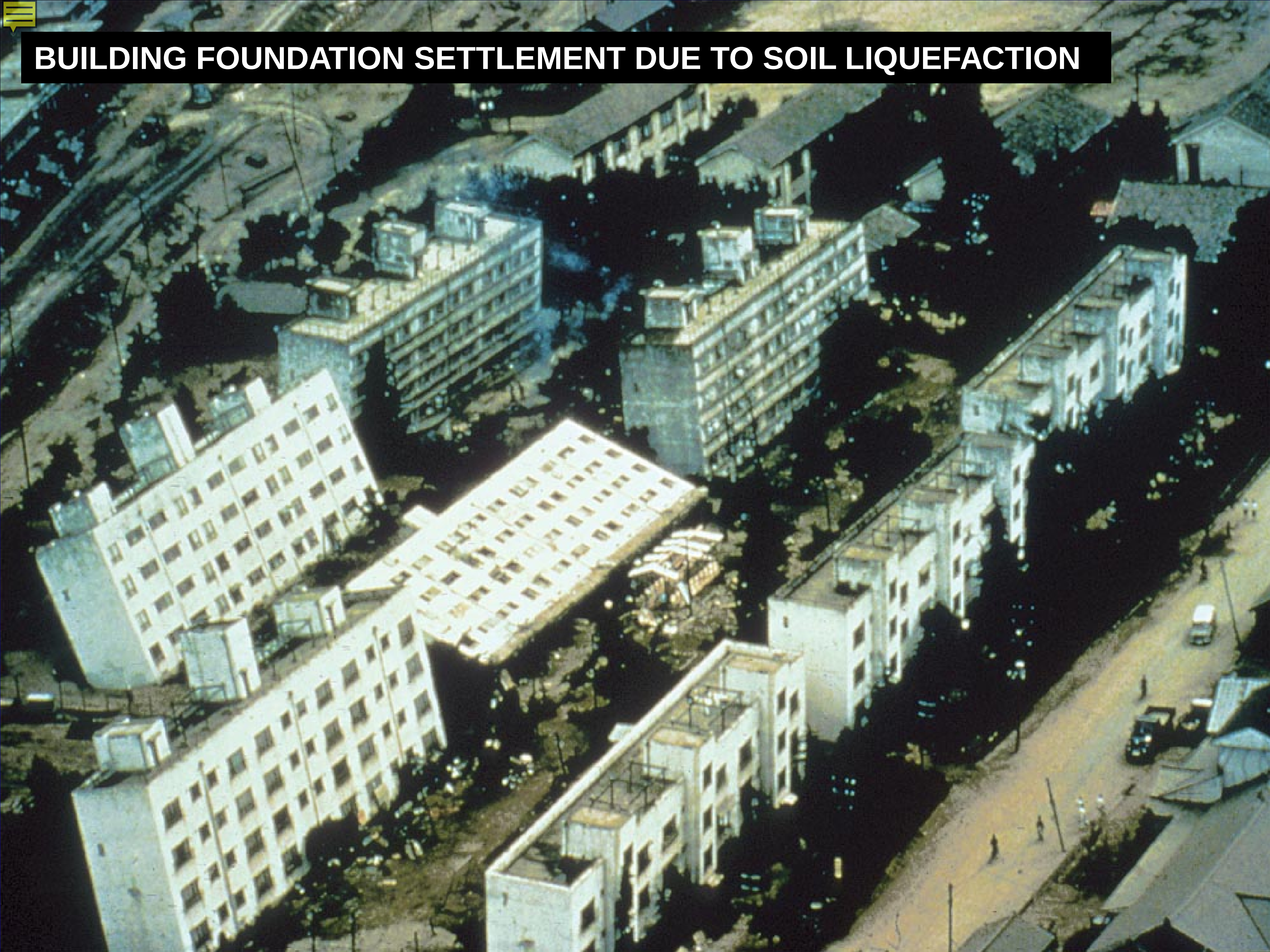
GROUND DISPLACEMENT

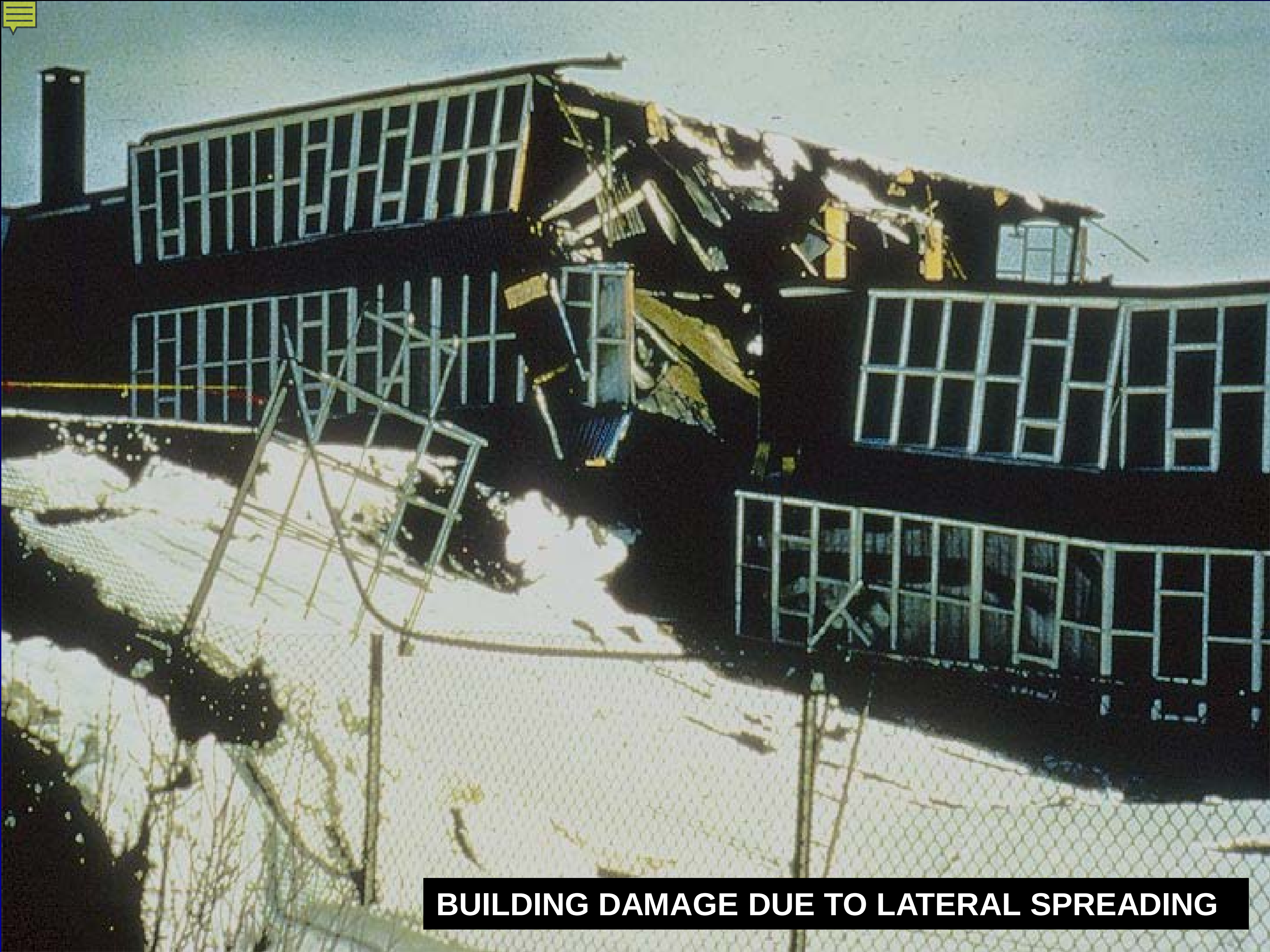




City of Seattle Liquefaction Zones

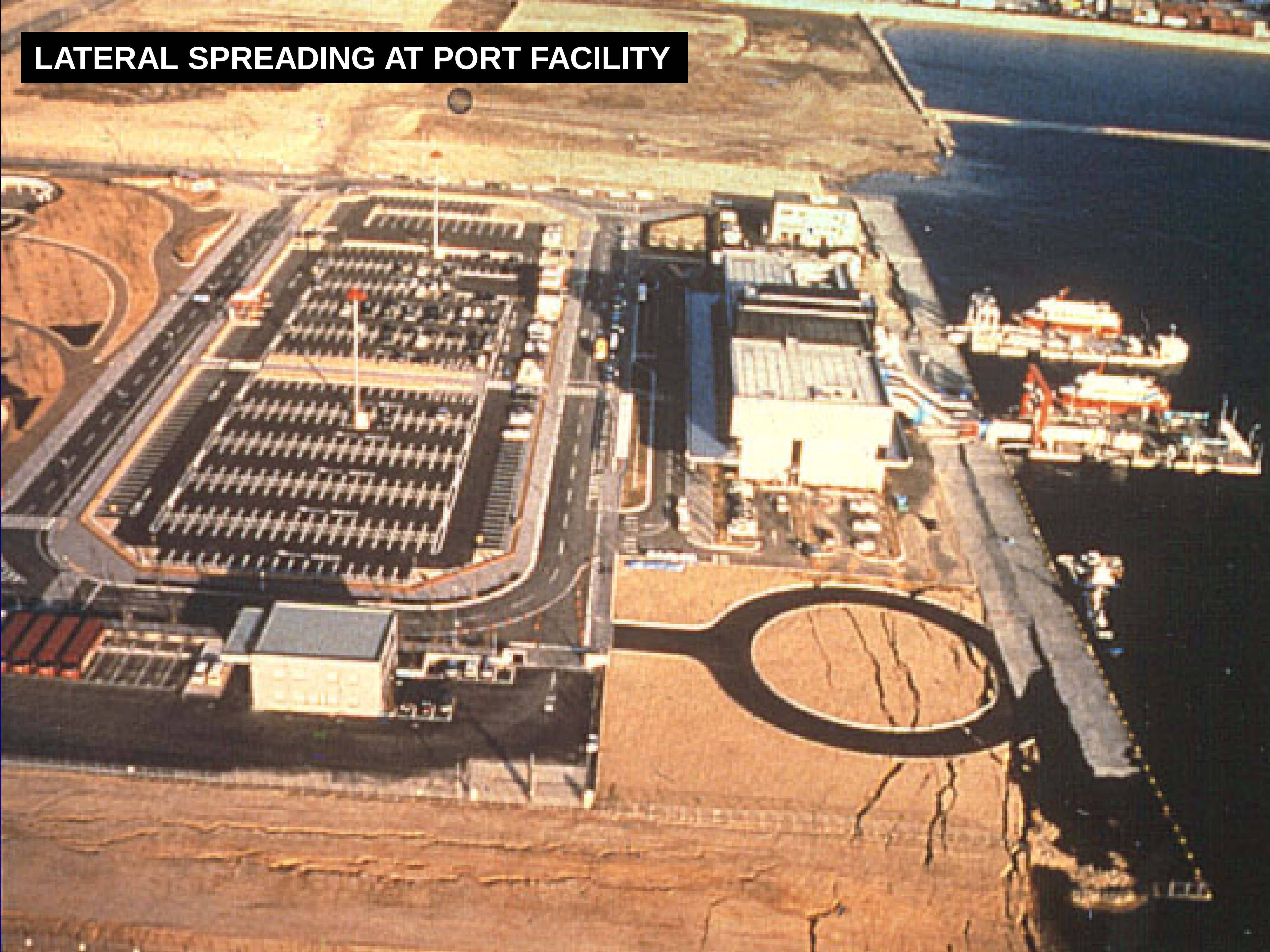
BUILDING FOUNDATION SETTLEMENT DUE TO SOIL LIQUEFACTION



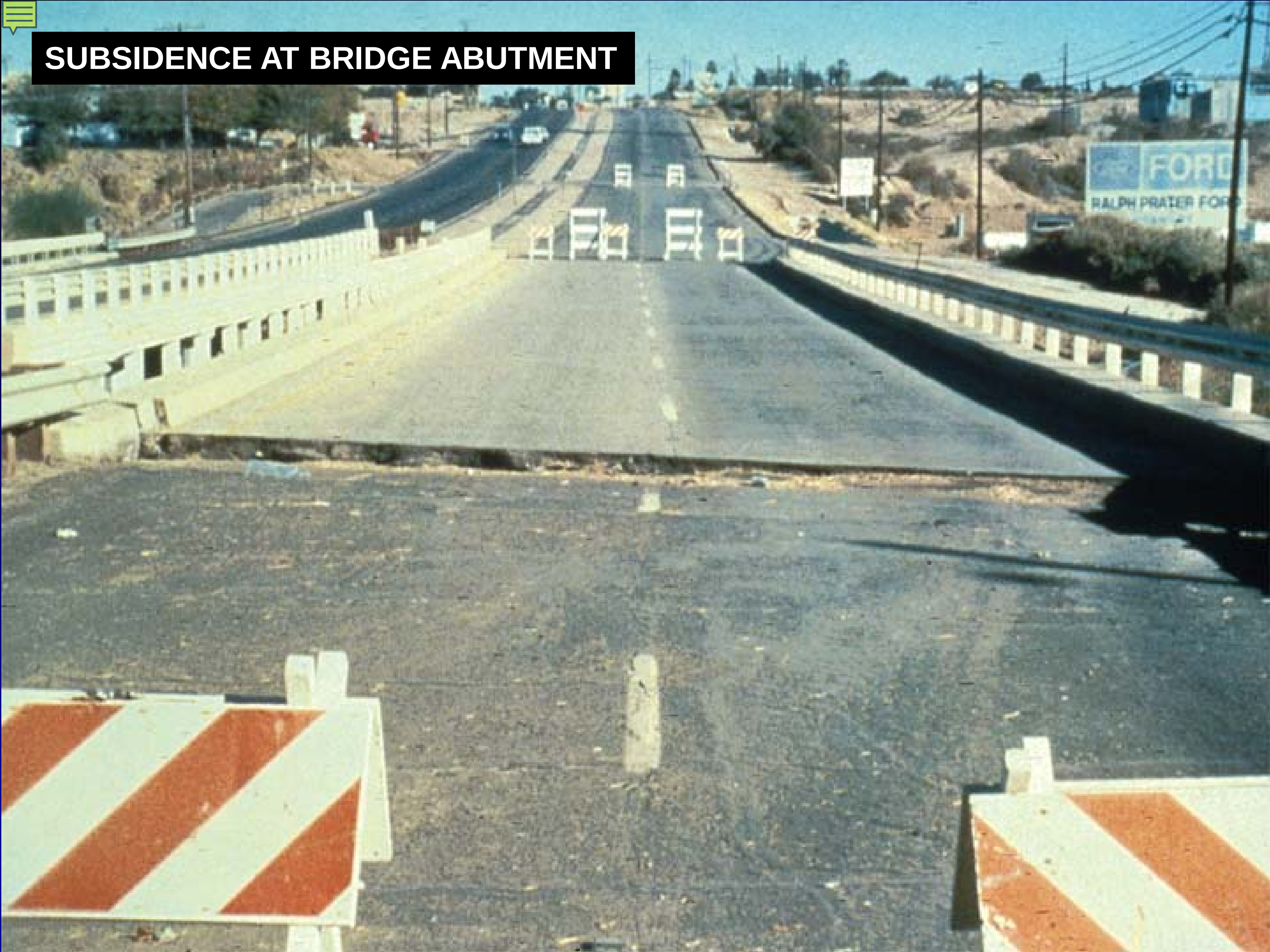


BUILDING DAMAGE DUE TO LATERAL SPREADING

LATERAL SPREADING AT PORT FACILITY

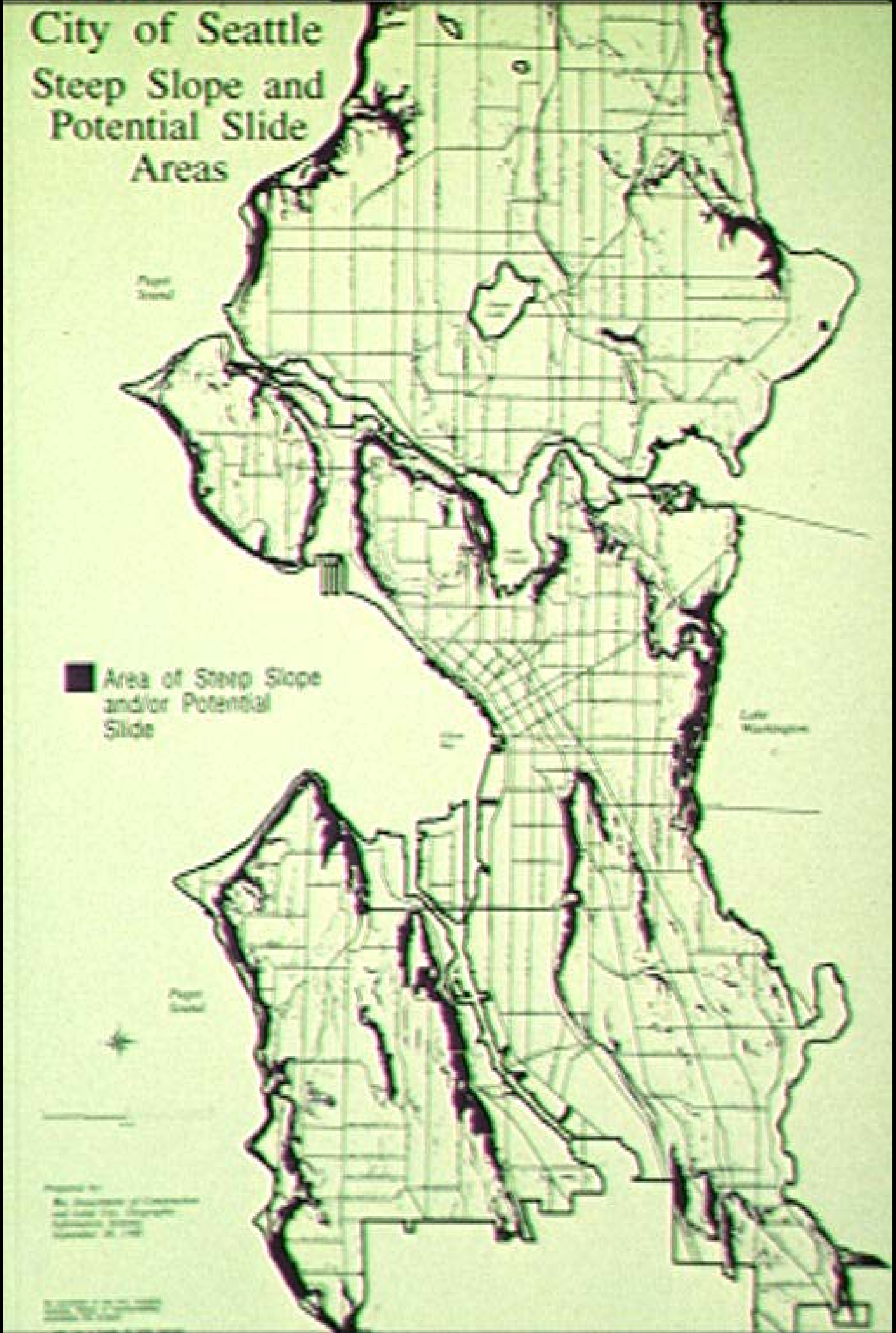


SUBSIDENCE AT BRIDGE ABUTMENT



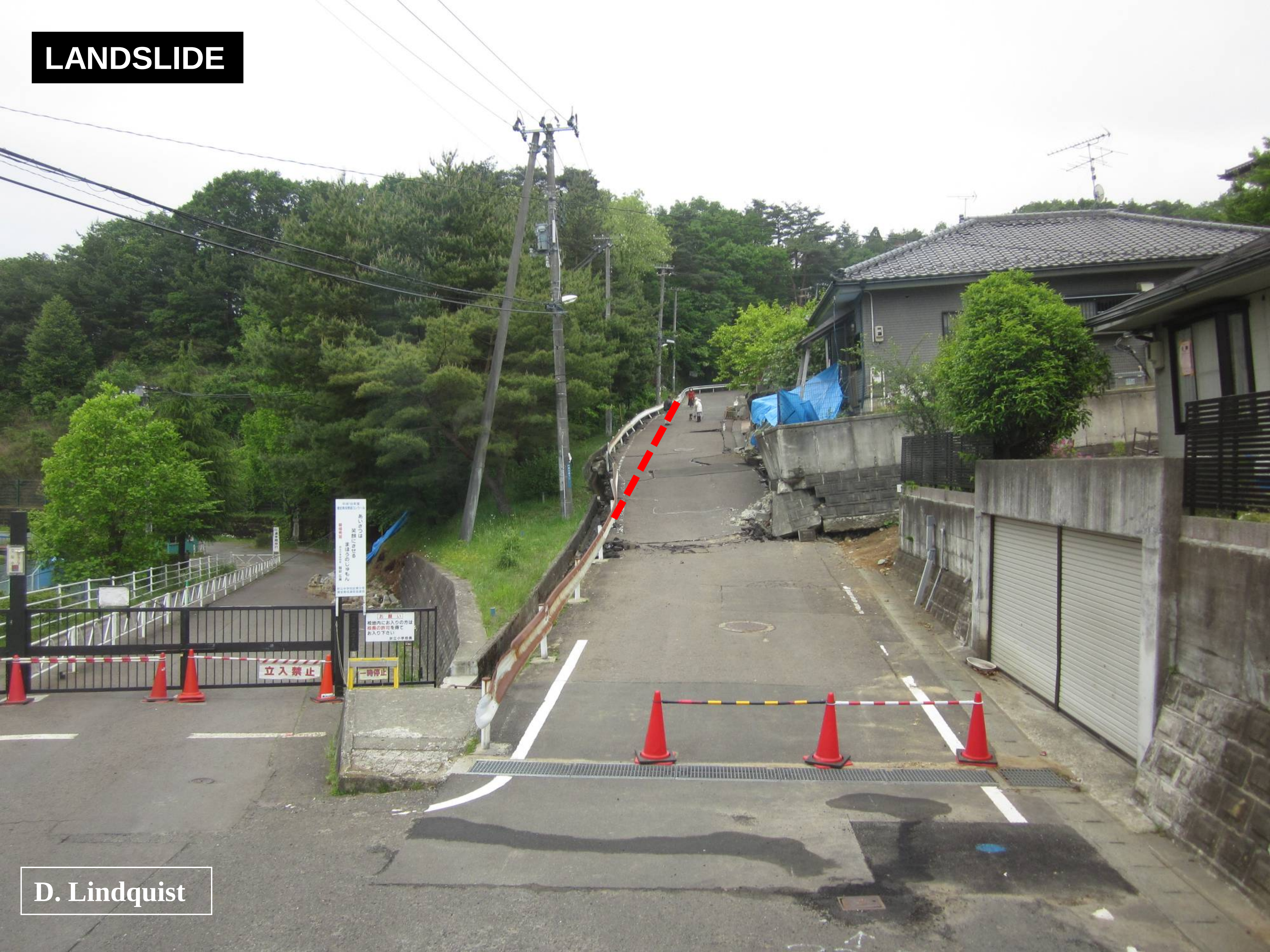
City of Seattle

Steep Slope and Potential Slide Areas



■ Area of Steep Slope and/or Potential Slide

LANDSLIDE

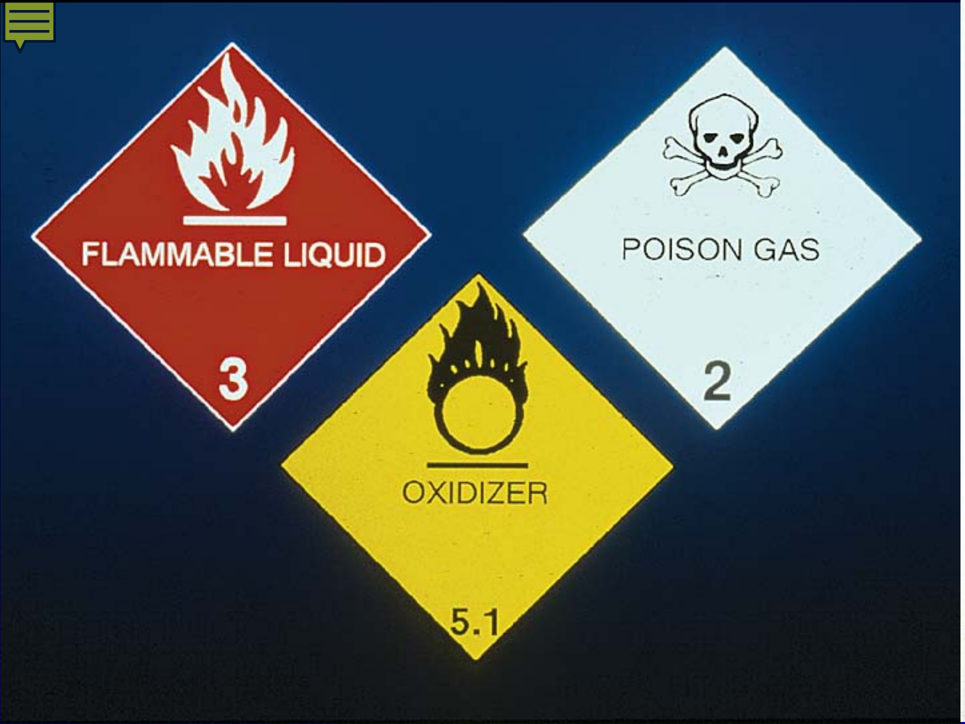


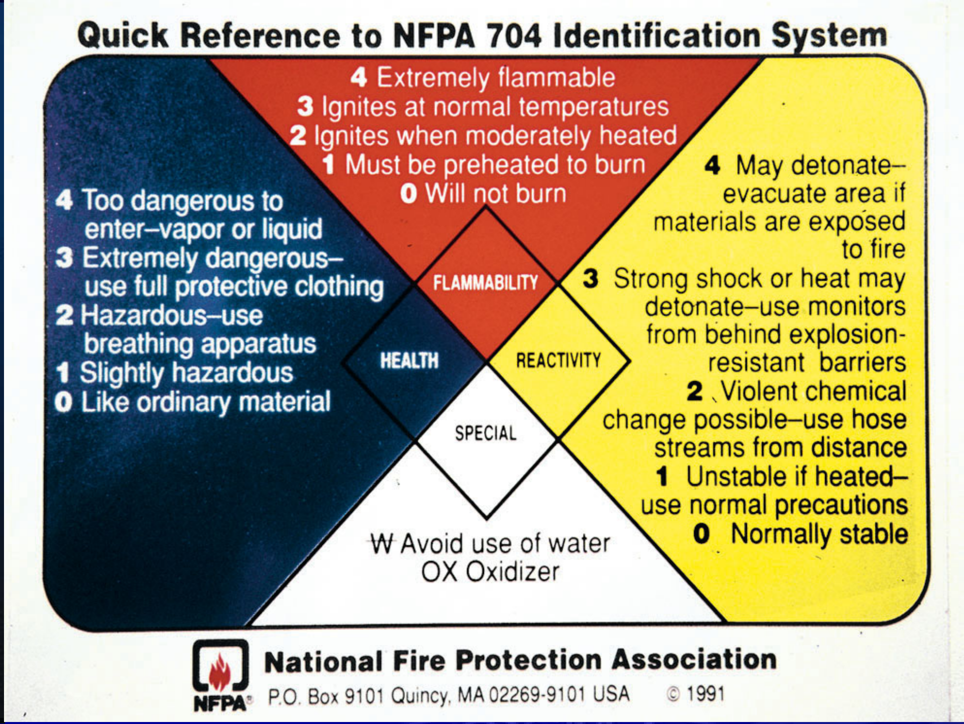
D. Lindquist

HAZARDOUS MATERIALS

Recognition – Type of facility
National Fire Protection Association (NFPA) diamond marker
Fumes, odors
Visible spills

Actions – Leave and post area
Notify fire department





Quick Reference to NFPA 704 Identification System

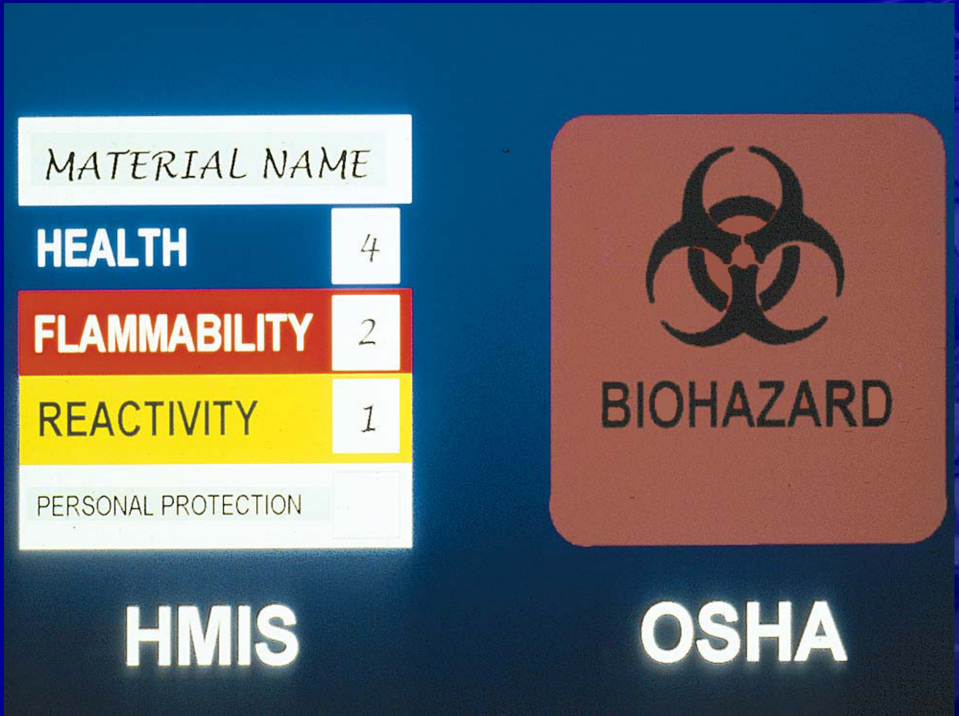
4 Extremely flammable
3 Ignites at normal temperatures
2 Ignites when moderately heated
1 Must be preheated to burn
0 Will not burn

4 Too dangerous to enter–vapor or liquid
3 Extremely dangerous–use full protective clothing
2 Hazardous–use breathing apparatus
1 Slightly hazardous
0 Like ordinary material

4 May detonate–evacuate area if materials are exposed to fire
3 Strong shock or heat may detonate–use monitors from behind explosion-resistant barriers
2 Violent chemical change possible–use hose streams from distance
1 Unstable if heated–use normal precautions
0 Normally stable

W Avoid use of water
OX Oxidizer

National Fire Protection Association
NFPA
P.O. Box 9101 Quincy, MA 02269-9101 USA
© 1991



HMIS

OSHA

SLIDE CREDITS

ASCE/SEI Chilean Earthquake Assessment Teams
Christopher Arnold
J. Marx Ayres
Gregg Brandow
California Office of Emergency Services
H. J. Degenkolb Associates
Jon Egan
Ronald P. Gallagher
Los Angeles Department of Building and Safety
John Meehan
National Fire Protection Association
National Oceanic and Atmospheric Administration
National Paint and Coatings Association
National Research Council

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San Francisco Bureau of Building Inspection
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Stephen D. Pfeiffer
RDD Consultants, Inc.
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